

Task 4 Report:

Evaluation of Alternative Confined Animal Facilities Criteria to Protect Groundwater Quality From Releases

Section 1 Introduction

Like most forms of agriculture, animal production has become more intensive and concentrated during the past 20 years. A majority of livestock is produced in facilities where grain and nutrients are fed to the animals in confined feeding areas such as pens or barns. Examples of confined animal facilities include cattle feedlots, dairies, and large swine and poultry production facilities. According to Ham and DeSutter (2000), about 60 percent to 80 percent of the nutrients, salts, pharmaceuticals, and other compounds fed to the animals are excreted as waste and remain onsite. Wastes from confined animal facilities typically include manure, urine, bedding, hair, spilled feed, and leachate from silage. Both wet and dry systems are used to manage these wastes. For example, in many instances, animal wastes from feeding and milk production areas are flushed with water to sumps that separate solids and direct the waste slurry to a system of wastewater retention ponds.¹ Dry management systems such as tractor or chain-pull scrapers are used by some operations to manage wastes from feeding areas and corrals.

The composition of animal manure depends on a number of factors such as the animal species, size, maturity, health, and composition of animal feed. Properly managed and applied to cropland at appropriate agronomic rates, the nutrients and some of the other constituents in animal manure can be used as a fertilizer and soil amendment for crops, including those crops used to feed the animals. However, the manure and its constituents, if not properly managed can cause pollution to occur in surface and ground water. The results of a four year investigation in Kansas (Ham 2002) demonstrated that seepage losses from animal waste retention ponds can affect groundwater quality if liquid effluent is not properly contained within the basin. Other areas within confined animal facilities such as corrals may also represent source areas with the potential to contaminate groundwater. Adriano et al. (1971) showed that shallow wells near corrals and other heavily manured areas could be contaminated with nitrate, and that the potential for nitrate contamination is exacerbated if the subsurface profile is sandy.

¹ For the purposes of this Task Report, wastewater “retention ponds” are analogous to animal waste “lagoons” or “impoundments.”



Final Report

The fact that waste management is a critical aspect of confined animal facility operations has not gone unnoticed by regulators. Since 1972, the Clean Water Act classified confined animal facilities as potential point sources of pollution. Federal regulations, however, focus on waste discharge to surface waters, while many states have regulations intended to protect groundwater (Brown, Vence & Associates [BVA] 2004). These regulations vary from state to state and frequently specify the maximum allowable seepage rate from animal waste lagoons and the minimum distance between the bottom of the lagoon and the static water table (see Table 1-1). In addition, some states also rely on the United States Department of Agriculture (USDA) guidelines that are included in Part 651 (Agricultural Waste Management Field Handbook) of the National Engineering Handbook that was issued by the USDA in 1992.

In California, Sections 22560 through 22565 of the California Code of Regulations (CCR) Title 27 set forth minimum standards for the discharge of animal wastes. The results of a previous evaluation (BVA 2003) concluded that site-specific data from Central Valley dairies and information included in published studies showed it was reasonable to conclude that current CCR Title 27 requirements are insufficient to prevent groundwater contamination from confined animal facilities, particularly in vulnerable geologic environments.² Moreover, because Title 27 does not explicitly require consideration of site-specific conditions as part of confined animal facility design and operations, the Regional Water Quality Control Board (RWQCB) cannot efficiently and reliably evaluate the nature and possible water quality consequences of animal waste discharges. In response to these findings, this Task Report was prepared to summarize the results of an evaluation of Alternative retention pond, milk production area, and corral design criteria intended to meet different performance goals specified by the Central Valley Regional Water Quality Control Board (CVRWQCB). The results of this evaluation were then used to recommend minimum criteria to protect groundwater quality from releases from confined animal facilities.

² “Vulnerable” geologic environments are assumed to include, but not limited to, areas where subsurface materials underlying the facility are relatively coarse-grained, where groundwater occurs at shallow depth, where contaminants may impact groundwater over time, or where other geologically unsuitable conditions are present

**Table 1-1
COMPARISON OF DIFFERENT STATE REGULATIONS REGARDING MAXIMUM ALLOWABLE
SEEPAGE RATE AND DISTANCE TO GROUNDWATER FOR LARGE SCALE ANIMAL WASTE
LAGOONS¹**

STATE	MAXIMUM SEEPAGE RATE (ft/day)	MINIMUM DEPTH TO WATER TABLE (ft)
Colorado	0.003	ns ⁽⁴⁾
Iowa	0.005	2
Kansas	0.021 or 0.0105 ⁽²⁾	10
Minnesota	0.0015 ⁽³⁾	2
Missouri	0.0015	4
Montana	0.0015	4
Nebraska	0.021	4
North Dakota	0.006	2
Oklahoma	0.0025	10
South Dakota	0.006	4
Texas	0.0015	ns

NOTES:

1. Table adapted from Ham and DeSutter (2000)
2. Seepage rate is dependent on size of operation and the type of closest water well (public or private)
3. Seepage rate of 0.0015 ft/day is based on National Resource Conservation Service (NRCS) guidelines for liner permeability and may not be directly comparable to maximum seepage rates depicted by other states.
4. ns - not specified

1.1 Purpose and Scope of Evaluation

1.1.1 Purpose of Investigation

In general, this Task Report focuses on evaluating alternative retention pond, milk production area, and corral criteria that will meet three different performance goals, providing an economic analysis of the proposed alternatives, and recommending minimum criteria that will protect groundwater quality. The specific objectives of this evaluation were to:

1. Evaluate alternative minimum design, siting, construction, maintenance, operational, and closure criteria for retention ponds, milk production areas, and/or corrals to meet specified performance goals at confined animal facilities. In accordance with CVRWQCB direction, the alternatives analysis was based on meeting the following three performance goals: (1) no release to the underlying



- geologic material; (2) no change in groundwater quality; and (3) some changes in groundwater quality but no exceedances of water quality objectives;
2. Provide an estimate of the costs associated with each of the proposed alternative criteria identified above;
 3. Select and recommend minimum siting, design, construction, maintenance, operation, and closure criteria for retention ponds, corrals, and milk parlors that will protect groundwater; and
 4. Provide an estimate of the total cost of implementing the recommendations and identify the potential sources of financing.

1.1.2 Approach and Scope

The scope of the evaluation included identification of containment system design factors and subsurface conditions important to confined animal waste impacts to groundwater, and completion of comparative fate and transport analyses for selected conservative (i.e., non-reactive) waste constituents. These data and evaluations were used to assess the relative influence of geologic conditions on the performance of various liners with respect to preventing groundwater contamination. As part of this work, alternative construction, operation, maintenance, and closure recommendations were qualitatively assessed for each design. Unit costs for each alternative were estimated based on contractor quotations, recent experience, and published cost documentation as appropriate. The alternative criteria and costs estimates were finally used to recommend minimum design, construction, siting, maintenance, operational, and closure criteria for retention ponds, milk production areas, and/or corrals at confined animal facilities that will protect groundwater quality. Due to dairy facilities being the majority of confined animal facilities in the Central Valley Region, this report focuses on the impact to groundwater from dairies.

1.2 Report Organization

The remainder of this Task Report is organized to present information generally as indicated under Approach and Scope:

- Section 2 provides background information from published studies regarding factors affecting the risk of groundwater contamination from confined animal facilities. This section also includes the results of numerical modeling performed to assess the relative influence of geologic conditions on the performance of various liners with respect to preventing groundwater contamination from retention ponds and corral areas. The published data and modeling results were extended to support the development of minimum criteria intended to protect groundwater quality.
- Section 3 addresses the performance goals that were specified for this evaluation and identifies limitations associated with use of these goals as the sole basis for developing minimum criteria to protect groundwater quality. To address these limitations, the section identifies the goals of the State's Antidegradation Policy as

the fundamental criteria to measure the performance of confined animal waste management facilities.

- Section 4 identifies and provides justification for a three-tiered series of criteria for retention ponds, corrals, and milk parlors to encompass increasing levels of groundwater quality protection to meet the identified performance goals. In general terms, each set of criteria is intended to represent the minimum criteria that will approach or meet the specified performance goals.
- Section 5 presents estimated costs for each Alternative. The cost estimates were based on an average size dairy facility design, construction, Construction Quality Assurance, maintenance, operations, and closure of one lagoon, corral (including freestalls), and milk parlor for 40 years of operation.
- Section 6 provides recommendations for minimum criteria based on the information included in the preceding sections. Because the level of groundwater protection will vary depending on site-specific conditions, it will be necessary for each facility to demonstrate it is in compliance with the State's Antidegradation Policy. Section 6 provides possible procedures that may be used in conjunction with best professional judgment to support such a demonstration.

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Section 2

Factors Affecting Groundwater Quality

The objective of this section is to identify and summarize those factors important to the protection of groundwater. This information was then used to draw conclusions regarding factors important to the development of minimum criteria to protect groundwater. The following discussion focuses on retention ponds and corrals because little significant information for milk parlors and potential impacts associated with milk parlor facilities or operations was found in the data reviewed as part of this evaluation.³

2.1 Groundwater Risk Factors

In general, the evaluation of potential impacts of animal waste management facilities requires consideration of the following three areas that largely decide the risk of groundwater contamination (Ham and DeSutter, 2000):

- Waste toxicity and concentration (i.e., the constituents in the wastes that pose a threat to water quality and public health);
- Waste loading to the subsurface (i.e., the rate at which soluble components in the waste seep from a lagoon or leach from a corral area under field conditions); and
- Aquifer vulnerability (i.e., soil properties, geology, and water table depth that affect the risk of waste movement from the near surface environment to the groundwater).

These factors are summarized in Table 2-1 and described below.

³ The primary function of a dairy is the production of milk, which typically occurs in milking parlors or barns. As required by CCR Title 3, the floors, curbs, gutters in the milking parlors must be constructed of concrete or other acceptable material and sloped to drain. These regulations also require that dirt or unpaved corrals or ramps shall not be located closer than 25 feet from the milking barn or closer than 50 feet from the milk house. No specific information for milk parlors and potential impacts associated with these aspects of confined animal operations on groundwater quality was found in the data reviewed as part of this evaluation. However, it is reasonable to assume that potential to impact groundwater quality should be limited assuming the milk parlor was constructed in accordance with sloping and drainage requirements and that the facility is inspected and maintained to limit cracking or defects in the concrete surfaces that may allow continued leakage or seepage to the subsurface.

Table 2-1 SUMMARY OF PRINCIPAL FACTORS THAT MUST BE CONSIDERED WHEN ASSESSING POTENTIAL EFFECTS OF CONFINED ANIMAL FACILITY WASTES ON GROUNDWATER QUALITY (Modified from Ham and DeSutter (2000))	
Toxicity and Concentration - Constituents in animal waste that could adversely affect groundwater quality	
a.	Inorganic constituents (nitrate N, ammonium N, salts, phosphorus, metals)
b.	Bacteria (fecal coliform, fecal streptococci)
c.	Enteric viruses
d.	Pharmaceuticals
e.	Concentrations of constituents in the waste (species, feed, management)
Input Loading - The rate at which constituents seep from a lagoon or leach from a corral into the underlying soil	
a.	Seepage rate (properties of liner system, depth of waste, sludge accumulation)
b.	Leaching rate (precipitation, waste accumulation)
Aquifer Vulnerability - Properties of the zone beneath the facility and the water table that affect the risk of groundwater contamination	
a.	Depth to groundwater (thickness of the vadose zone)
b.	Soil properties (rate of contaminant transport, biochemical transformations)
c.	Geology (geologic layers that inhibit or promote contaminant movement)
d.	Preexisting groundwater quality

2.1.1 Waste Toxicity and Concentration

Constituents in confined animal wastes that could affect groundwater include nutrients (nitrogen, phosphorous, and potassium compounds), salts, pathogens, hormones, and pharmaceuticals. The types and concentrations of these compounds are dependent on species, diet, veterinary care, climate, time of year, and the characteristics of the waste handling systems. Typical waste constituents and concentrations associated with retention pond, corral, and milk parlor wastes are summarized in Tables 2-2, 2-3, and 2-4.

As described in BVA (2003), the principal constituents of concern with respect to groundwater quality are nitrate and salt compounds. Nitrogen occurs in several different forms (or "species") in the natural environment and undergoes transformations from one form to another as environmental conditions change. For example, nitrogen is present in fresh manure as organic-N (nitrogen in proteins and other organic molecules), ammonia and ammonium (the ionic form of ammonia dissolved in water), nitrate, and nitrite. Ammonia is volatile and as much as 60 percent of the ammonia is typically lost to the atmosphere within hours after excretion. Ammonium is very soluble in water but is relatively immobile in soils with clay content of 15 percent or more (Ham 2002). Under aerobic conditions, ammonium typically oxidizes to nitrite and nitrate. Nitrate is both soluble and mobile in soils of all types, provided that aerobic conditions are maintained. As a result, nitrate is typically considered to be a "conservative" (i.e. non-reactive, non-retarded) constituent in the subsurface.

Dairy manure contains significant amounts of soluble salts (BVA 2003). For example, significant concentrations of soluble salts containing sodium and potassium that remain from undigested feed may pass unabsorbed through animals. Other major constituents contributing to manure salinity are calcium, magnesium, chloride, sulfate, bicarbonate, and

Evaluation of Alternative Confined Animal Facilities Criteria

carbonate. Salts are of concern because some salt constituents (e.g. the anion compounds chloride, sulfate, and bicarbonate) are mobile and increased salinity can impair beneficial uses of groundwater (CVRWQCB, 1995, 1998).

Table 2-2 CHEMICAL AND PHYSICAL CHARACTERISTICS OF WASTE FROM ANAEROBIC LAGOONS USED TO CONTAIN ANIMAL WASTE							
PARAMETER	UNITS	SWINE (20 Sites)			CATTLE (20 Sites)		
		Max	Min	Avg	Max	Min	Avg
NO ₃ ⁻	mg/L	1.4	<1.0	<1.0	1.0	<1.0	<1.0
NH ₄ ⁺ + NH ₃ ⁻ -N	mg/L	1540.0	180.0	910.2	510.0	10.0	170.0
Total N	mg/L	4730.0	210.0	1080.0	785.0	70.0	285.0
Organic N	mg/L	1190.0	30.0	169.6	275.0	30.0	115.0
Total Phosphorus	mg/L	1307.0	9.0	150.4	132.0	18.0	49.0
Potassium	mg/L	3621.0	328.0	1098.0	2172.0	190.0	659.5
Sulfur	mg/L	400.0	10.0	56.7	130.0	10.0	40.0
Calcium	mg/L	1400.0	40.0	194.8	435.0	90.0	190.0
Magnesium	mg/L	338.0	6.0	41.4	181.0	42.0	96.5
pH	units	8.5	6.5	8.1	8.1	7.1	7.8
Sodium	mg/L	970.0	90.0	329.3	740.0	50.0	206.0
Chloride	mg/L	2007.0	195.0	497.4	1956.0	131.0	549.5
BOD	mg/L	2370.0	860.0	1605.1	1871.0	246.0	522.5
COD	mg/L	3066.0	1550.0	2603.0	2338.0	1710.0	1734.0
TSS	mg/L	420.0	140.0	283.3	2540.0	240.0	694.0
EC	mmhos/cm	28.0	2.7	8.9	10.2	1.7	4.6
TDS	mg/L	17920.0	1747.0	5783.3	6528.0	1056.0	2694.0
SAR(a)	unitless	35.3	8.7	21.8	30.2	2.8	10.2
NOTES: 1. Data from Ham (2002) 2. BOD - biological oxygen demand; COD - chemical oxygen demand; TSS - total suspended solids; EC - specific conductance; TDS - total dissolved solids; SAR(a) - sodium adsorption ratio (adjusted)							



Final Report

Table 2-3 SUMMARY OF SATURATED PASTE CHEMISTRY OF SAMPLES FROM THE SURFACE OF ACTIVE FEEDLOT PEN SURFACES			
CONSTITUENT	UNITS	MEAN CONCENTRATION	STANDARD DEVIATION
pH	units	7.5	0.2
EC	mS/cm	53	13
Na ⁺	mg/L	3423	1977
Ca ²⁺	mg/L	805	332
Mg ²⁺	mg/L	711	414
K ⁺	mg/L	9328	3
Cl ⁻	mg/L	12648	2812
SO ₄ ⁻	mg/L	3414	2563
NO ³ -N	mg/L	10.4	3.6
NH ⁴ -N	mg/L	586	308
NOTES: 1. Data from Maule ¹ and Fonstad (2000) 2. Samples were collected from a depth of about 0.5 ft from four different facilities			

Table 2-4 SUMMARY OF DAIRY WASTE CHARACTERIZATION MILKING CENTERS					
COMPONENT	UNITS	MILKING CENTER			
		Milk Room	Milk Room + Milk Parlor	Milk Room + Milk Parlor + Holding Area ^a	Milk Room + Milk Parlor + Holding Area ^b
Volume	ft ³ /day/1,000 lbs	0.22	0.6	1.4	1.6
Moisture	%	99.72	99.4	99.7	98.5
Total solids	% wet basis	0.28	0.6	0.3	1.5
Volatile solids	lb/1,000 gal	12.9	35	18.3	99.96
Fixed solids	lb/1,000 gal	10.6	15	6.7	24.99
COD	lb/1,000 gal	25.3	41.7	ND	ND
BOD	lb/1,000 gal	ND	8.37	ND	ND
N	lb/1,000 gal	0.72	1.67	1	7.5
P	lb/1,000 gal	0.58	0.83	0.23	0.83
K	lb/1,000 gal	1.5	2.5	0.57	3.33
C:N ratio	unitless	10	12	10	7
NOTES: 1. All data from EPA (2003). 2. ^a Holding area scraped and flushed – manure removed via solids separator. 3. ^b Holding area scraped and flushed – manure included. 4. ND – No Data.					

2.1.2 Input Loading

The rate at which soluble wastes move from a lagoon to the underlying soil or leach to the groundwater from corral areas is an important groundwater contamination risk factor. As summarized below, input loading refers to the movement of material from a lagoon or the surface of a corral to the underlying geologic materials and is largely a function of the design and constructed characteristics of the facility. It is important to note that input loading does not consider the fate and transport of the contaminants once they move into the soil.

2.1.2.1 Anaerobic Lagoons

Anaerobic lagoons are often used for collecting, storing, and treating wastes at confined animal facilities. Most waste lagoons consist of earthen basins that are between about 1 to 6 acres in area and that are 10 to 20 feet deep (Ham and DeSutter 2000). At cattle feedlots and dairies, much of the wastewater entering the retention ponds is runoff from precipitation that has fallen on open areas. Washwater from feeding areas, milking parlors, and other areas is also frequently drained into the retention ponds. Conversion of organic matter to methane and carbon dioxide gases through anaerobic digestion removes about 50 percent to 80 percent of the manure solids that initially enter a retention pond and up to 80 percent of the nitrogen in the waste may be lost from the retention pond surface by ammonia volatilization. Despite the efficiency and convenience of anaerobic retention ponds, the liquid waste may contain a number of other potential contaminants at relatively high concentrations (Table 2-2).

The potential for these contaminants to seep from the retention pond and enter the surrounding soil depends largely on the hydraulic conductivity of the liner system and the depth of waste in the retention pond. Published studies clearly show that the hydraulic conductivity of many soil liners is reduced by the organic sludge that blankets the bottom of the retention pond (e.g. Chang et al. 1974; Ham 2000). A recent laboratory study (Maule' et al. 2000) showed that swine waste reduced flow through compacted liners by 2 or 3 orders of magnitude, independent of soil texture, to an effective hydraulic conductivity of about 1×10^{-7} cm/sec. Maule' et al. (2000) concluded that reductions in flow were caused by clogging of soil pores at the uppermost portion of the liner. Ham (2002) measured whole-retention pond seepage rates using water balance techniques and the results from the seepage tests were combined with data on liner thickness and basin geometry to calculate the apparent hydraulic conductivity of the compacted soil liners. The results of these analyses were similar to Maule' et al. (2000) and indicated most liners had hydraulic conductivities between 1×10^{-7} cm/sec and 3×10^{-7} cm/sec.⁴ Ham (2002) noted that under field conditions,

⁴ According to Ham (2002), the low variance in seepage rates among lagoons is not surprising because manure that has undergone anaerobic digestion in a lagoon probably has a relatively standard particle size distribution. Ham (2002) also notes that a thin sludge-affected layer will dominate the overall hydraulic conductivity of the liner when its conductivity is much smaller than that of the compacted-soil layer. The relative importance of the sludge-affected layer diminishes as the conductivity of the compacted-soil layer decreases. Thus, the sludge layer will probably have little effect on lagoon seepage if the basin is built with a thick liner made of heavy clay or if it is excavated in thick natural clay deposits. On the other extreme, if the operator simply excavates a pit and starts

Final Report

processes such as freezing-thawing, erosion, macropore formation, and wetting-drying may compromise the liner along the shoreline and cause greater seepage losses than would be predicted based on liner thickness, hydraulic conductivity, and depth of waste.

Despite the relatively low hydraulic conductivity associated with most soil-lined waste retention ponds, data indicate that ammonium and organic nitrogen will build up under animal waste retention ponds over the life of a facility and that large reservoirs of ammonium can be deposited under retention ponds even when seepage rates are low. For example, Ham (2002) reports annual export rates through compacted soil liners from cattle feedlot retention ponds that averaged about 343 pounds per acre per year for ammonium and between 890 to 2,680 pounds per acre per year for chloride. Whether or not input loading of this magnitude will ultimately affect groundwater above some specified limit will depend on subsurface conditions (aquifer vulnerability).

2.1.2.2 Corral/Feedlot Areas

The data shown in Table 2-3 show relatively high concentrations of potential contaminants which may be present at or very near the ground surface in corral areas. Research in several states with climates ranging from arid to humid indicates, however, that an active feedlot surface can develop a compacted manure/soil interface layer that is typically 2 to 4 inches thick and can reduce water infiltration rates to as little as 3 percent of the infiltration rate of the underlying soil (Sweeten, undated). Mielke and Mazurak (1976) show that water intake into undisturbed feedlot soils below the manure pack is extremely slow (from 0.38×10^{-2} cm/day to 2.3×10^{-2} cm/day) and that the manure/soil interface layer in corrals helps maintain conditions favorable to denitrification (reducing conditions) and restricts movement of water through the soil.

Although limiting infiltration can restrict the leaching of salts, nitrates, and ammonium into the subsurface, data indicate it does not eliminate input loading to the subsurface. The results of one study (Chang et al. 1973) showed a significant increase in nitrate, chloride, and organic matter in the first 10 feet of the soil profile under a corral compared to a control site where no history of agricultural activities had been recorded.⁵ Based on these studies, Chang et al. (1973) concluded the accumulation of dairy waste on the surface of an unpaved corral would encourage the leaching of nitrate, chloride, and organic matter into the underlying soil strata and this magnitude of leaching can be substantial for a long period of time. Chang et al. also noted, however, that the leaching rate can be slow in semiarid climates.

Adriano et al. (1971) also reported average concentrations of ammonium-nitrogen and nitrate-nitrogen in soil profiles corrals that were considerably higher than in control areas, particularly in the 0 ft to 2 ft depths below corrals. Significantly, nitrate and total salt concentrations in groundwater from shallow wells near the corrals were higher than in

adding waste where native permeabilities are high, the sludge will probably cause an appreciable decrease in conductivity over the first few weeks of operation.

⁵ The average nitrate concentration of the saturation extract ranged from 15 to 87 ppm NO₃-N in the corral while the average at the control site was 10 ppm NO₃-N.

deeper wells that were also located near the corrals. Based on those results, Adriano et al. (1971) concluded that shallow wells near corrals and other heavily manured areas could be contaminated with nitrate. This finding was consistent with Maule' and Fonstad (2000) who studied five feedlots and concluded that four of the five feedlots showed evidence of groundwater contamination from manure (depths to groundwater were all less than 13 feet at these facilities).

2.1.3 Aquifer Vulnerability

Ultimately, the effect of waste toxicity and input loading on groundwater quality is dependent on aquifer vulnerability. The fate and transport of contaminants that seep from a retention pond or leach from a corral area are largely determined by complex subsurface processes that occur in the vadose zone. The physical and chemical properties of the soil profile that govern this movement can be very difficult to quantify and may include cation exchange capacity, unsaturated permeability, soil structure, the presence or absence of preferential flow paths, precipitation patterns, and microbial transformations that can convert compounds from one form to another.

Perhaps the most important factor affecting groundwater vulnerability is the depth to the static water table because research has shown that the probability of finding contamination caused by retention ponds and corrals decreases rapidly as the depth to groundwater increases (Ham and DeSutter 2000; Sweeten, undated; Maule' and Fonstad, 2000). This is probably because a large portion of the nitrogen and the cation salts adsorbed to the soil at the base of a retention pond or corral are fixed and relatively immobile. The referenced data all suggest that ammonium, organic nitrogen, and cation concentrations return to background levels within 5 to 10 feet of the ground surface. However, chloride (an anion) is probably transported a much greater distance because the negatively charged ions do not adsorb to soil particles (Ruhl, 1999; Ham and DeSutter, 2000).

Significantly, once a retention pond is dewatered, cleaned, and/or closed, the diffusion of oxygen into the contaminated zone could promote the conversion of a large reservoir of ammonium and organic nitrogen to nitrate (Ham and DeSutter, 2000). Nitrate is highly mobile in the soil and represents a greater environmental hazard. Similarly, feedlots or corrals that have been abandoned without manure removal may be more likely to pollute groundwater as oxygen is introduced to the subsurface and the stored ammonium is converted to nitrate (Sweeten, undated; Chang et al., 1973). This information suggests that the greatest risk of groundwater contamination from retention ponds and corrals may occur after a facility is no longer in use.

2.2 Numerical Modeling

Analytical modeling was performed to assess the relative influence of geologic conditions on the performance of various liners with respect to preventing groundwater contamination. Principal modeling procedures and results are summarized below. Additional information regarding the modeling effort is presented in Appendix A.



Data (e.g. BVA 2003) shows the principal pollutants associated with animal wastes with the potential to affect groundwater quality include nitrogen compounds (particularly nitrate) and salts. However, models that accurately simulate site-specific conditions and the complex interactions and transformations associated with these contaminants and with different geologic materials in the subsurface, are not available (Ham 2002). As a result of these limitations, a simplified approach was used to assess the potential fate and transport of nitrate and chloride from retention ponds and from corral areas at a hypothetical facility. Four subsurface profiles were modeled, representing the possible combinations of homogeneous sand or clay materials and depths to groundwater of 5 to 10 feet or 150 feet below the ground surface. Retention pond leakage analyses considered steady-state conditions and were based on assumed leakage rates representative of clay-lined and geosynthetic-lined impoundments. Corral analyses considered transient conditions and were based on assumed loading conditions and on precipitation data for the Madera area of the Central Valley.

Both the steady-state and the transient analyses are linear, which means the model-predicted concentrations of nitrate and chloride in groundwater are linear functions of the input concentrations. As a result, the ratio of leakage or loading rates to concentration in groundwater will remain constant if all other factors are held equal. This feature allowed use of the model results to draw several broad conclusions regarding potential groundwater impacts from confined animal facilities. The most significant of these conclusions being:

- Retention pond leakage will ultimately lead to an increased concentration of nitrate and chloride in the groundwater under any of the geologic and liner scenarios that were assumed for analysis. The predicted ratio of input leakage concentration to groundwater concentration under different conditions ranged from 1 (essentially no dilution) for clay-lined basins underlain by sand or clay, to a value of 0.0013 (or an input dilution of about 754) for a high-quality synthetic-lined basins underlain by clay soils.
- Although leakage rates and subsurface soil types under retention ponds influence contaminant concentrations in groundwater from retention pond seepage, the results indicate that leakage rate is the dominant factor governing the degree of groundwater impacts. These results are based on steady-state analyses that do not consider time. At low leakage rates, low subsurface permeability, and a thick vadose zone, the time required to reach groundwater is likely to be very long as summarized below. Also note that it may or may not be possible to reduce groundwater impacts to the performance goals of no exceedances of water quality objectives or no change in groundwater quality by reducing the leakage rate. The impact of reducing the leakage rate depends upon site factors such as preexisting groundwater quality, analytical methods, matrix inferences, etc.
- Transient flow analyses of corral areas indicate that the geologic setting of a facility largely determines the vulnerability of groundwater from nitrate and chloride leaching. In particular, clay significantly delays nitrate and chloride migration to the groundwater. For example, the model calculates breakthrough times as short as 0.08

years for a facility that is underlain by sand with the groundwater table 10 feet below the ground surface or 8.1 years for the same facility with the groundwater occurring at a depth of 150 feet below the ground surface. By comparison, the assumption of clay subsurface conditions increases the breakthrough time to 31 years and more than 350 years for the shallow and deep groundwater conditions, respectively. The type of chemical constituents did not affect the amount of time required to reach the groundwater in this analysis because both nitrate and chloride were assumed to be non-reactive. Reducing the assumed hydraulic conductivity of the subsurface soil from 1×10^{-6} cm/sec to 3×10^{-7} cm/sec increased the breakthrough time to 75 years for groundwater occurring at a depth of 10 feet below the ground surface to 480 years for groundwater at a depth of 150 feet below the ground surface, all other factors being equal.

- The transient corral analyses also indicated that a reduced infiltration rate that would result from a low permeable layer under the corral could lead to an approximate 50 percent decrease in relative chloride concentrations in shallow groundwater below the facility (assumed to be 10 feet below the ground surface).

These results are consistent with published findings (Ham and DeSutter 2000) that a large unsaturated zone between a retention pond and the water table is a clear advantage because mobile ions such as nitrate and chloride move slowly in unsaturated soil. The results also support the conclusions that depth to the static water table is an important factor affecting groundwater vulnerability and that limiting leakage or loading from the facility is a significant variable.

2.3 Implications

The model results described above and summarized in Table A-4 indicate that the risk of groundwater contamination at any facility is not only dependent on the seepage rate from waste retention ponds or the leaching rate from corral areas, but also depends on the chemical characterizations in the waste, the depth to the water table, and the subsurface soil properties that influence waste transformation and migration in the subsurface. Ham and DeSutter (2000) argue that site-to-site variation in these properties is so great that retention pond design should be site specific and also state that “no science-based framework exists for collecting site-specific input data and calculating the appropriate design criteria for each individual lagoon.” However, the data and modeling support several broad and largely intuitive conclusions important to the development of minimum criteria intended to protect groundwater quality:

- Limiting retention pond seepage or infiltration from corral areas reduces the potential for and degree of future groundwater impacts;
- The presence of clay minerals in the liner system and/or the underlying geologic materials reduces the potential for future groundwater impacts because of their adsorptive capacity for ammonium, organic nitrogen, and cation salts. However, modeling results and data indicate that anions or non-reactive contaminants such as nitrate may ultimately affect groundwater;



Final Report

- A large unsaturated zone between a retention pond and the water table is an advantage because some compounds adsorb to the clay particles and mobile ions such as nitrate and chloride move slowly in unsaturated soil as the hydraulic conductivity of this zone decreases with declining water content; and
- The greatest risk of groundwater contamination from retention ponds and corrals may occur after a facility is no longer in use and ammonium bound to soil particles may convert to nitrate and eventually migrate to the groundwater.

Section 3

Performance Goals

3.1 Antidegradation Policy Requirements

The fundamental performance goal for confined animal facility waste management is conformance with the State's Antidegradation Policy. This policy requires waste disposal be regulated as to achieve the highest water quality consistent with maximum benefit to the people of the state. Specific Antidegradation Policy requirements applicable to this study include:

1. Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water, and will not result in water quality less than that prescribed in the policies.
2. Any activity which produces or may produce a waste or increased volume of concentration of waste and which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained.

3.2 Specified Performance Goals

The three different performance goals specified for this project represent compliance with the State's Antidegradation Policy. For example:

- A discharger in compliance with the performance goal of no release to the underlying geologic materials would be in compliance with the Antidegradation Policy. This performance goal may be necessary for a facility where the underlying geologic materials do not have sufficient physico-chemical properties to attenuate any constituents of concern that may be released and/or the existing groundwater is already polluted with these constituents of concern;
- A discharger in compliance with the performance goal of no change in groundwater quality would be in compliance with the Antidegradation Policy. This performance goal may be applicable where the underlying geologic materials have sufficient physico-chemical properties to attenuate any constituents of concern that may be released and the underlying groundwater is deep and has assimilative capacity or for a discharger who cannot demonstrate that any change in high quality groundwater will be consistent with the maximum benefit to the people of the state; and



- A discharger in compliance with the performance goal of some change in groundwater quality but no exceedances of water quality objectives would also be in compliance with the Antidegradation Policy if it can be demonstrated that the change in water quality is consistent with the maximum benefit to the people of the State and pollution or nuisance will not occur because best practicable treatment or control (BPTC) of the discharge has been implemented. This performance goal may be applicable where groundwater has assimilative capacity and where the underlying geologic materials have sufficient physico-chemical properties to attenuate any constituents of concern that may be released.

Providing scientific justification that any particular minimum criteria will meet a particular numeric performance goal is problematic because the performance of any Alternative is highly site-specific (i.e., a criterion that provides acceptable performance in one environment may not be effective in another environment), strict compliance with the goal may not be technically feasible, and/or analytical tools are not generally available to provide a definitive quantitative demonstration of compliance. This is consistent with published studies that note site-to-site variation in waste and subsurface characteristics is so great that retention pond design should be site specific and that no science-based framework currently exists for collecting input data and calculating an appropriate design criterion for individual confined animal facility retention ponds (Ham and DeSutter 2000). Particular limitations associated with the performance goals specified for this evaluation are summarized below.

3.2.1 No Release to the Underlying Geologic Material

A performance goal of no release to the underlying geologic material implies no leakage whatsoever from confined animal facility retention ponds, milk parlors or corrals. Corrals are usually open and unlined, and by definition this goal could not be met without some form of separation or liner system to prevent waste contacting the underlying geologic material. Moreover, although concrete is typically used for floors in milk parlors, some leakage over time may reasonably be expected due to cracks or defects in the concrete. Lined retention ponds also cannot reasonably meet this goal because seepage rates from earthen-lined storages are not zero (Ham 2002) and a finite (though small) leakage rate may be expected from containment systems that include relatively impermeable geosynthetic materials (Bonaparte et al. 2002).⁶ NRCS (1997) also notes that no soil or artificial liner, even concrete or a geomembrane liner, can be considered impermeable. These conclusions are supported by the results of the steady-state modeling that indicate some level of contamination will eventually migrate to groundwater even assuming a very low level of leakage consistent with high quality construction. Therefore, strict compliance with this

⁶ Bonaparte et al. (2002) notes that average monthly leakage through geomembrane/geosynthetic clay liner (GCL) composites constructed with construction quality assurance (CQA) will often be less than 2 liters per hectare per day (lphd), but occasionally in excess of 10 lphd. Bonaparte et al. (2002) also conclude that leakage from single primary geomembrane liner systems constructed with CQA (but without ponding tests or electrical leak location surveys) will often be less than 50 lphd, but occasionally in excess of 200 lphd. These leaks occur through pinhole-sized (1mm-diameter) defects that result from manufacturing flaws and from installation defects (1 cm²-area) resulting from seaming faults and punctures during installation.

performance goal is not feasible. However, as described in more detail in Section 4, criteria that provide for redundancy, detection, containment, collection of seepage, and monitoring, can approach this level of protection.

3.2.2 No Change in Groundwater Quality

For the purposes of this analysis, the performance goal of no change in groundwater quality is assumed to mean that confined animal facility waste constituents may be released from a unit, but they will never reach the groundwater. The results of the simplified modeling performed for this study (see Appendix A) suggest that wastes from retention ponds and corrals will ultimately reach the groundwater, although the time required for this to occur can be a great many years for facilities underlain by clay and where groundwater occurs at depth. The retention pond modeling results further suggest that groundwater will ultimately be impacted even assuming the very low leakage rates associated with well-constructed synthetic liners, although, under the less vulnerable geologic conditions, the resulting increase in groundwater concentrations may be very low. Whether or not measurable changes in groundwater quality would occur depends on a number of factors such as the increased contaminant concentrations, preexisting groundwater quality, analytical methods, sample quality, etc. In reality, there are significant difficulties associated with demonstrating whether or not a particular design criteria will meet a goal of no change in groundwater quality because models that accurately simulate site-specific conditions and the complex interactions and transformations of wastes and different geologic materials in the subsurface are not available (Ham 2002). As a result, a rigorous and unambiguous analytical demonstration that this performance goal can be met by a given minimum criterion is not feasible at this time. However, as described further in Section 6, a simplified model that evaluates the movement of the more conservative constituents of concern (such as chloride) in the subsurface at a specific facility, may be appropriate as one of several tools that could be used to make a best professional judgment regarding the ability of specific design criteria to meet this performance goal.

3.2.3 No Exceedances of Water Quality Objectives

The performance goal of some changes in groundwater quality but no exceedances of water quality objectives is assumed to apply only where natural background groundwater quality is less than the water quality objectives because the Basin Plans do not require improvement over naturally occurring background concentrations. Where natural background concentrations are less than water quality objectives, the State's Antidegradation Policy allows some changes in water quality under special conditions, but does not allow the resulting water quality to be less than that prescribed in the policies as described in Section 3.1. For confined animal facilities located in agricultural areas where groundwater may already be polluted by nitrate or other contaminants such as salts, groundwater limitations may be based on water quality objectives as specified in the Basin Plans. Therefore, application of the water quality objectives is partially dependent on natural background and site-specific groundwater quality.

Final Report

For the same reasons as described in Section 3.2.2, it is infeasible at this time to demonstrate that this performance goal can be met by a given minimum criteria. However, simplified models may be used as tools to evaluate the ability of specific design criteria at a particular facility to meet this performance goal.

Water quality objectives for the Central Valley are specified in 1998 “The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board, Central Valley Region, Fourth Edition - 1998, The Sacramento River Basin and the San Joaquin River Basin,” and the 1995 “Water Quality Control Plan for the Tulare Lake Basin, Second Edition - 1995.” In general, these plans require the following objectives for all groundwaters of the Sacramento, San Joaquin, and Tulare Lake basins:

- **Bacteria.** In groundwaters used for domestic or municipal supply the most probable number of coliform organisms over any seven-day period shall be less than 2.2/100 mL.
- **Chemical Constituents.** Groundwaters shall not contain chemical constituents in concentrations that adversely affect beneficial uses. At a minimum, groundwaters designated for use as domestic or municipal supply shall not contain concentrations of chemical constituents in excess of the maximum contaminant levels (MCLs) specified in the following provisions of CCR Title 22: Tables 64431-A (Inorganic Chemicals) and 64431-B (Fluoride) of Section 64431; Table 64444-A (Organic Chemicals) of Section 64444; and Tables 64449-A (Secondary Maximum Contaminant Levels - Consumer Acceptance Limits) and 64449-B (Secondary Maximum Contaminant Levels - Ranges) of Section 64449. At a minimum, water designated for domestic or municipal supply shall not contain lead in excess of 0.015 mg/L. The Basin Plans note that the RWQCB may apply more stringent than the MCLs if necessary to protect beneficial uses.
- **Radioactivity.** At a minimum, groundwaters designated for use as domestic or municipal supply shall not contain concentrations of radionuclides in excess of the MCLs specified in Table 4 (MCL Radioactivity) of Section 64443 of CCR Title 22.
- **Tastes and Odors.** Groundwater shall not contain taste- or odor-producing substances in concentrations that cause nuisance or adversely affect beneficial uses.
- **Toxicity.** Groundwaters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life associated with beneficial uses(s). This objective applies regardless of whether the toxicity is caused by a single substance or the interactive effect of multiple substances.
- **Pesticides (Tulare Lake Basin Plan).** No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. At a minimum, waters designated as municipal supply shall not contain concentrations of pesticide constituents in excess of the MCLs specified in Table 64444-A (Organic Chemicals) of Section 64444 of CCR Title 22. The Tulare Lake Basin Plan notes that

the RWQCB may apply more stringent requirements than the MCLs if necessary to protect beneficial uses.

- **Salinity (Tulare Lake Basin Plan).** All groundwaters shall be maintained as close to natural concentrations of dissolved matter as is reasonable considering careful use and management of water resources.⁷ As a result, the Tulare Lake Basin Plan provides for a maximum annual increase in salinity measured as electrical conductivity (ranging from an increase of 1 to 6 umhos/cm) determined from monitoring data by calculation of a cumulative average annual increase over a 5-year period.

3.2.4 Application of Goals to Current Evaluation

Based on the aforementioned factors, at this time it is infeasible to accurately and quantitatively demonstrate that any specific criteria will result in compliance with any of the specified performance goals for all confined animal facilities in the Region. However, the minimum Alternative criteria proposed in Section 4 may be considered BPTC under certain site-specific conditions. As such, these criteria can approach the level of protection necessary to meet the three specified performance goals under the specified site conditions. Whether or not an Alternative will represent BPTC for a particular facility will depend on site-specific factors. Therefore, it is assumed that it will be the responsibility of each facility owner or operator to demonstrate what criteria (minimum or other more stringent criteria developed by the discharger) represents BPTC and are sufficient to meet the appropriate performance goal in order to comply with the State's Antidegradation Policy.

⁷According to the Tulare Basin Plan, "no proven means exist at present that will allow ongoing human activity in the Basin and maintain ground water salinity at current levels throughout the Basin. Accordingly, the water quality objectives for ground water salinity control the rate of increase." The Basin Plan notes that the salinity objectives have never been studied to determine their adequacy in promoting the Boards goal of minimizing the rate of salinity increase in the Tulare Lake Basin.

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Section 4

Identification of Alternative Minimum Criteria

As summarized in the preceding section, it is infeasible to accurately and quantitatively demonstrate compliance with the specified performance goals at this time. Similarly, it is not possible to specify unique prescriptive standards that will meet the performance goals in all possible conditions. However, it is possible to identify minimum criteria that will approach or meet the specified performance goals. Therefore, for the purposes of this evaluation, a three-tiered series of minimum design, construction, operations and maintenance, and closure criteria were identified to encompass increasing levels of groundwater quality protection that are intended to approach or meet the specified performance goals of no exceedances of water quality objectives, no change in groundwater quality, and no release to the underlying geologic materials. It is assumed it will be the responsibility of each facility to demonstrate what criteria represent BPTC and are sufficient to meet the appropriate performance goals to comply with the State's Antidegradation Policy.

4.1 Site Characterization

Whether or not an Alternative criteria will represent BPTC for a particular facility will depend on site-specific factors and the design and permitting for any facility must be based on a representative assessment of those site conditions important to groundwater quality protection. Therefore, all of the Alternative minimum criteria identified in this section rely on a detailed site characterization study as a precursor to design. That such a study is necessary and justified is emphasized by Ham and DeSutter (2000) who note that site-to-site variation in subsurface properties is so great that design must be site-specific. Site information is also necessary to assess background groundwater quality, define the applicable performance goal to meet Antidegradation Policy requirements, and to complete a demonstration that a facility has implemented BPTC sufficient to meet the identified performance goal.

Proposed minimum site characterization requirements are summarized in Table 4-1. As indicated in this table, it is recommended that the results of this evaluation and the associated data be submitted to the CVRWQCB in the form of a Report of Waste Discharge (ROWD). Consistent with the State's Antidegradation Policy implementation as specified in the Basin Plans, the ROWD must include an analysis of the impacts and potential impacts of the discharge on water quality, as measured by background concentrations and applicable water quality objectives. The ROWD should also include identification of the BPTC measures to be taken to minimize or prevent groundwater quality degradation and an analysis of the ability of the BPTC measures to meet the applicable performance goals.

Evaluation of Alternative Confined Animal Facilities Criteria

Table 4-1
SUMMARY OF MINIMUM SITE CHARACTERIZATION REQUIREMENTS FOR CONFINED ANIMAL FACILITY DESIGN AND PERMITTING

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
Design and Preconstruction	All	<p>Completion of a site characterization study prepared by a qualified professional, shall be submitted to the RWQCB in the form of a ROWD. The report at a minimum shall incorporate the planning and design investigation procedures described in Section 6501.704 (Site Investigations for Planning and Design) included in Chapter 7: Geologic and Ground Water Considerations of the Agricultural Waste Management Field Handbook (NRCS 1999) and shall include the following minimum information:</p> <p>A. Depth to first groundwater: B. Depth to first useable groundwater for human consumption: The source of potable water for the facility and nearby properties, and the safeguards to protect that water source must be identified. C. Proximity to watercourses: Adjacent watercourses and improvements to protect watercourses from discharges from a facility into watercourses or water bodies must be identified. D. Properties of the subsurface soil and rock (e.g., composition and properties, hydraulic conductivity, soil consolidation and compression, shrink swell potential, soil corrosivity, etc.). E. Cut and fill slope stability under static and pseudo static (earthquake) conditions; F. Erosion potential. G. Proposed design details for retention ponds, corrals, barns, and milk parlors sufficient to demonstrate compliance with the appropriate performance goal. H. Construction testing and inspection requirements sufficient to demonstrate construction in accordance with the approved plans and specifications for the project. I. Data regarding background and existing groundwater quality.</p>	<p>Whether or not an Alternative will represent BPTC for a particular facility will depend on site-specific factors and the design and permitting for any facility must be based on a representative assessment of those site conditions important to groundwater quality protection. As a result, all of the Alternative criteria rely on a detailed site characterization study as a precursor to design. Such a study is also necessary to provide the information necessary to assess background groundwater quality, define the applicable performance goal to meet Antidegradation Policy requirements, and to complete a demonstration that a facility has implemented BPTC sufficient to meet the identified performance goal.</p>

4.2 Alternative 1 (No Release to Underlying Geologic Materials)

This Alternative represents the most robust (or conservative) criteria and could reasonably be assumed to represent the BPTC to limit to the maximum extent feasible, the potential release to underlying geologic materials through the use of protective and essentially impermeable materials, redundancy, CQA, regular maintenance and monitoring, and closure procedures. This Alternative is appropriate where the underlying geologic materials do not have sufficient physico-chemical properties to attenuate any constituents of concern that may be released and/or the existing groundwater is already polluted with these constituents of concern. The proposed criteria and associated rationale and justification for the recommendations are summarized in Table 4-2. Principal items associated with the criteria are summarized below.

4.2.1 Siting

The intent of this criteria is to prevent release to the geologic materials underlying the facility, and as a result, site-specific subsurface characteristics are less important for this Alternative than for other less robust criteria with respect to protecting groundwater.

Vulnerable geologic conditions such as high groundwater elevations, high quality groundwater, permeable soils or rock, and little to no attenuation capability could require the implementation of this Alternative. However, as shown in Section 2, depth to the groundwater table is one of the most significant factors affecting the potential for groundwater contamination from retention ponds and corrals (Ham and DeSutter 2000). Therefore, as a minimum criteria and to conform with the Tulare Lake Basin Plan (CVRWQCB, 1995), this Alternative recommends that retention ponds, corrals, and milk parlors be sited, designed, constructed, and operated to ensure that the contained wastes will be a minimum of five feet above the highest anticipated elevation of underlying ground water.

4.2.2 Design (Containment System)

Containment to meet a no release to underlying geologic materials performance goal includes double-lined retention ponds with a leachate collection and removal system; sloping and a composite lining system under corral areas; and concrete waterproofing with secondary containment beneath the floor of milk parlors. Primary liner systems for the retention pond include geomembranes (GM) to reduce the potential for seepage or leaching to the greatest extent practicable.⁸ Redundancy through a secondary composite liner for the retention ponds is warranted because data (Bonaparte et al., 2002) show that some amount of seepage is likely to occur through geomembranes even when constructed with strict CQA

⁸ State Water Resources Control Board (SWRCB) Resolution 93-62 (Policy for Regulation of Discharges of Municipal Solid Waste) requires composite liners to have an upper component consisting of a synthetic liner at least 40-mils thick (or at least 60-mils thick if the liner consists of high density polyethylene [HDPE]).

procedures and the modeling performed for this investigation indicates that conservative compounds will ultimately reach the groundwater even at very low seepage rates.

The secondary composite liner is recommended to include a GM/compacted clay liner (CCL) or a GM/geosynthetic clay liner (GCL). The purpose of the CCL or GCL component of the secondary liner is to act as a filter for some waste constituents that may penetrate the overlying GMs. Consistent with SWRCB Resolution 93-62, the CCL, if constructed, should be at least two feet thick and have a hydraulic conductivity of 1×10^{-7} cm/sec or less; GCL should have a hydraulic conductivity of 1×10^{-9} cm/sec. In other states, the intermediate leachate collection and removal system may consist of granular or geosynthetic materials and will act to minimize seepage by limiting the buildup of head on the secondary liner that may result from seepage through the primary liner. However, the CVRWQCB does not approve the use of geosynthetic materials in leachate collection systems due to problems associated with biological clogging. An intermediate leachate collection and removal system should be of sufficient thickness and permeability to effectively remove fluid that may leak through the primary liner. At a minimum, if granular materials are used we recommend a sand layer of two inches be used. The primary criterion for the thickness of sand is the ability to control the thickness during placement. The recommended permeability for sand is 1×10^{-3} cm/sec. An operations layer is also recommended which is 2 feet thick and consists of local natural material, such as soil, to protect the liners. Depending upon the types of granular or native materials employed at the specific site, geosynthetic cushion materials may be necessary to protect the primary liner and/or secondary liner from damage from the operations layer and LCRS layer, respectively.

The composite liner for the corral area should be consistent with the retention pond secondary composite system. Corrals should be sloped consistent with the requirements of CCR Title 3, Division 2, Chapter 1, Article 22: "A minimum of three percent slopes shall be maintained in unpaved corrals where the available space for each animal is 400 square feet or less. The slope in areas more than 400 square feet per animal may be reduced proportionately to not less than 1-1/2 percent at 800 square feet or more per animal." An operations layer is also recommended which is 2 feet thick and consists of local natural material, such as soil, to protect the liners. All construction of liners should be in accordance with a CQA plan. Depending upon the types of granular or native materials employed at the specific site, geosynthetic cushion materials may be necessary to protect the liner from damage from the operations layer.

Milk parlors should be underlain by a redundant containment system that includes concrete flooring constructed to meet the requirements of CCR Title 3, Division 2, Chapter 1, Article 22, concrete sealant, and secondary containment beneath the milk parlor concrete flooring that consists of a geomembrane that meets the thickness requirements of SWRCB resolution 93-62 (see footnote 8).

4.2.3 Construction Quality Assurance

The importance of good CQA procedures is demonstrated by Bonaparte et al. (2002) who show that leakage through synthetic liner systems can be highly variable depending on the

installation procedures. Ham and DeSutter (2000) note performance based testing will provide additional incentives for engineers and contractors to maintain quality control throughout the design and construction phases. Accordingly, this Alternative criteria requires retention pond and corral construction to be carried out in accordance with a CQA plan certified by an appropriately registered professional to satisfy the requirements currently specified in CCR Title 27 §20324. Because this criteria represents the most conservative design and is intended to prevent seepage from the retention pond or leaching from a corral to the underlying geologic materials to the maximum extent feasible, it includes an electronic leak detection test requirement for geomembrane layers upon completion of installation. This testing is justified based on data (Bonaparte et al. 2002) that indicate leakage from single primary geomembrane liner systems constructed with CQA but without electrical leak location surveys will occasionally exceed of 200 liters per hectare per day (lphd).

4.2.4 Operations and Maintenance

Routine inspections and maintenance represent best management practices to ensure that the containment systems continue to function as designed. Accordingly, this Alternative includes weekly inspections to observe the integrity of the containment systems for retention ponds, corrals, and milk parlors. The Alternative also includes regular and timely maintenance to address and correct any deficiencies noted during the inspections. Maintenance criteria also include annual removal of manure and solids from the retention pond and semi-annual removal for manure from corral areas. These activities are justified to reduce potential contaminant loading to the subsurface and it is recommended that an Operations and Maintenance Plan be prepared that includes procedures for cleaning out the retention ponds and corrals without damaging the underlying liners.

4.2.5 Monitoring

Groundwater and vadose zone monitoring is recommended as part of this criteria to assess whether the retention pond or corral is meeting its overall objective of no release to the underlying geologic materials. Background monitoring is necessary to determine if a release to groundwater has occurred. Specific data are not available to assess the potential for groundwater impacts resulting solely from milk parlor wastes. However, it is reasonable to assume that the potential for groundwater impacts from these wastes is sufficiently remote that specific monitoring is not required assuming design, construction, operation, maintenance, and closure in accordance with the requirements of this Alternative.

4.2.6 Closure

This criteria assumes retention pond and corral closure will include removal of the waste materials and subsurface testing of the underlying soil for major ions to a depth of 10 feet (minimum) below the base of the retention pond and corral. Soil testing to a minimum of 10 feet below the base of milk parlors is necessary if there is evidence of significant leakage. Testing is justified because data (Maule' and Fonstad, 2000; Sweeten, undated; Ham and DeSutter, 2000) show that the greatest risk to groundwater contamination may occur when a retention pond or corral is closed or removed from service because a significant amount of



nitrogen and salt compounds can build up in the soil under these facilities even with low leakage rates. With the introduction of oxygen, the nitrogen compounds can transform to mobile and toxic forms that represent an appreciable risk to groundwater. The available data (Ham and DeSutter 2000, Sweeten, undated) show that these adsorbed constituents are usually confined to the upper 3 meters below the retention pond or corral.

Closure activities for retention ponds, corrals and/or milk parlors in the event a significant amount of waste materials are indicated by the testing program should include excavation and disposal of the affected soil or insitu treatment to render the compounds immobile. Excavation and disposal or insitu treatment is justified based on data that indicate: (1) in the presence of oxygen, some of the compounds bound to the soil can transform to more mobile forms and migrate to the groundwater; and (2) comparative numerical modeling performed for this study shows the conservative compounds will ultimately impact groundwater at some level.

4.3 Alternative 2 (No Change in Groundwater Quality)

This Alternative is generally intended to address the performance goal of no change to underlying groundwater quality and represents an intermediate minimum criteria that is slightly less robust than Alternative 1 but that is more protective than Alternative 3. Similar to Alternative 1, this Alternative limits potential changes to groundwater quality through siting requirements, the use of protective and essentially impermeable materials, redundancy, CQA, regular maintenance and monitoring, and closure procedures. This Alternative is appropriate where the underlying geologic materials have sufficient physico-chemical properties to attenuate any constituents of concern that may be released, and the underlying groundwater is deep and has assimilative capacity or for a discharger who cannot demonstrate that any change in high quality groundwater will be consistent with the maximum benefit to the people of the state. The proposed criteria and associated rationale and justification for the recommendations are summarized in Table 4-3. Principal items associated with the criteria are summarized below.

4.3.1 Siting

The intent of this criteria is to prevent a change in groundwater quality below a facility. The data described in Section 2 indicate some seepage (although very small) is likely to occur from retention ponds and corral areas even assuming relatively impermeable liner construction. The modeling results described in Section 2 show that the presence of low-permeability soils (clay) can increase the amount of time required for contaminants to reach the groundwater. As a result, this criteria includes performance based siting requirements to provide some attenuation capacity for waste constituents that seep or leach from retention ponds or corrals.

Also as shown in Section 2, depth to the groundwater table is one of the most significant factors affecting the potential for groundwater contamination from retention ponds and corrals (Ham and DeSutter 2000). Therefore, as a minimum criteria and to conform with the Tulare Lake Basin Plan (CVRWQCB, 1995), this criteria recommends that retention ponds,

corrals, and milk parlors be sited, designed, constructed, and operated to ensure that the contained wastes will be a minimum of five feet above the highest anticipated elevation of underlying ground water.

4.3.2 Design (Containment System)

Containment to meet a no change in groundwater quality performance goal includes a composite liner under retention ponds, a protected compacted clay liner (CCL) or geosynthetic clay liner (GCL) under corral areas, and concrete waterproofing on the concrete floors of milk parlors. The composite liner system for retention ponds includes a 60-mil geomembrane to reduce the potential for seepage or leaching to the greatest extent practicable. Redundancy through a GCL or CCL beneath the geomembrane is warranted because data (Bonaparte et al., 2002) show that some amount of seepage is likely to occur through a geomembrane even when constructed with strict CQA procedures. Additionally, the modeling performed for this investigation indicates that conservative compounds will ultimately reach the groundwater even at very low seepage rates. The clay in the GCL or CCL will act to filter and attenuate some of the waste constituents. Consistent with SWRCB Resolution 93-62, the CCL, if constructed, should be at least two feet thick and have a hydraulic conductivity of 1×10^{-7} cm/sec or less. A GCL, if used, should have a hydraulic conductivity of 1×10^{-9} cm/sec or less. The liners should be protected by a layer of operations soil at least 2 feet thick that does not include angular rock fragments or other materials that may damage the underlying liner. The purpose of the operations layer is to protect the liner from damage. Depending upon the types of granular or native materials employed at the specific site, geosynthetic cushion materials may be necessary to protect the liner from damage from the operations layer.

The data presented in Section 2 indicates relatively high concentrations of nitrate and chloride can build up under corrals even assuming very low infiltration and limited leaching resulting from a manure seal layer at the base of the corral. Data (Adriano et al., 1971, Sweeten, undated; Maule' and Fonstad, 2000) and the modeling performed for this study show that these compounds ultimately can cause changes in groundwater quality. Accordingly, the recommended criteria includes requirements for corral slopes consistent with CCR Title 3, Division 2, Chapter 1, Article 22 (described in Section 4.2.2) and reducing the leaching potential of these compounds with either a one-foot-thick (minimum) CCL or a GCL to limit the potential for such changes. The CCL, if constructed, should have a hydraulic conductivity of 1×10^{-7} cm/sec or less. A GCL, if used, should have a hydraulic conductivity of 1×10^{-9} cm/sec or less. The integrity of the CCL or GCL should be protected by a layer of operations soil at least 2 feet thick that does not include angular rock fragments or other materials that may damage the underlying liner. Depending upon the types of granular or native materials employed at the specific site, geosynthetic cushion materials may be necessary to protect the liner from damage from the operations layer.

The design criteria for milk parlors includes the requirements of CCR Title 3, Division 2, Chapter 1, Article 22 and waterproofing the concrete surfaces with a sealant to minimize infiltration of wastes and wash water through cracks or defects in the concrete.



4.3.3 Construction Quality Assurance

The importance of good CQA procedures is demonstrated by Bonaparte et al. (2002) who show that leakage through synthetic liner systems can be highly variable depending on the installation procedures. Accordingly, this Alternative criteria requires retention pond and corral liner construction to be carried out in accordance with a CQA plan certified by an appropriately registered professional to satisfy the requirements currently specified in CCR Title 27 §20324. Because this criteria represents a relatively conservative design and is intended to limit seepage from the retention pond to the underlying geologic materials to the maximum extent feasible, it includes an electronic leak detection test requirement for all geomembrane layers upon completion of installation. This Alternative also requires that concrete flooring and gutter construction in milk parlors be tested to ensure conformance with the material specifications for the project.

4.3.4 Operations and Maintenance

Routine inspections and maintenance represent best management practices to ensure that the containment systems continue to function as designed. Accordingly, this Alternative includes weekly inspections to observe the integrity of the containment systems for retention ponds, corrals, and milk parlors. The Alternative also includes regular and timely maintenance to address and correct any deficiencies noted during the inspections. Maintenance criteria also include annual removal of manure and solids from the retention pond and semi-annual removal for manure from corral areas. These activities are justified to reduce potential contaminant loading to the subsurface. An Operations and Maintenance plan should be prepared that includes procedures for cleaning out the retention pond and corral without damaging the underlying liners.

4.3.5 Monitoring

Groundwater and vadose zone monitoring is recommended as part of this criteria. Groundwater and vadose monitoring is justified to provide a means to assess whether the retention pond or corral is meeting its overall objective of no changes in groundwater quality. Background monitoring is necessary to determine if a release to groundwater has occurred. Specific data are not available to assess the potential for groundwater impacts resulting solely from milk parlor wastes. However, it is reasonable to assume that the potential for groundwater impacts from these wastes is sufficiently remote that specific monitoring is not required assuming construction, operation, maintenance, and closure in accordance with the requirements of this Alternative.

4.3.6 Closure

This criteria assumes retention pond and corral closure will include removal of the waste materials and lining systems and subsurface testing of the underlying soil for major ions to a depth of 10 feet (minimum) below the base of the retention pond and corral. Testing is justified for the reasons described in Section 4.2.6. The available data (Ham and DeSutter 2000, Sweeten, undated) show that nitrogen and some salt compounds that are adsorbed in the soils are usually confined to the upper 3 meters below the retention pond or corral.

In the event a significant amount of waste materials are indicated, closure should include excavation and disposal of the affected soil or insitu treatment to render the compounds immobile. Excavation and disposal or insitu treatment is justified based on data that indicate: (1) in the presence of oxygen, some of the compounds bound to the soil can transform to more mobile forms and migrate to the groundwater; and (2) comparative numerical modeling performed for this study shows the conservative compounds will ultimately impact groundwater at some level.

4.4 Alternative 3 (No Exceedance of Water Quality Objectives)

This Alternative represents minimum criteria that is generally intended to prevent exceedances of water quality objectives for the Central Valley of California. This Alternative is the least robust of the three Alternatives and is intended to minimize potential changes in groundwater quality through siting requirements, proper design and construction, CQA, regular maintenance and monitoring, and closure procedures. This Alternative may be applicable where groundwater has assimilative capacity and where the underlying geologic materials have sufficient physico-chemical properties to attenuate any constituents of concern that may be released. Principal items associated with the standard are summarized below.

4.4.1 Siting

The intent of this criteria is to prevent exceedances of groundwater quality objectives applicable to a particular facility. According to NRCS (1997), waste management structures must be located in soils with acceptable permeabilities or be lined. Because the NRCS guidelines include a compacted soil liner for retention ponds as a minimum, some seepage will occur and the modeling results included in Section 2 show that conservative compounds that leak from a retention pond are likely to ultimately reach the groundwater. The modeling results also indicate, however, that subsurface conditions can appreciably dilute these compounds and significantly delay breakthrough time. As a result, this criteria include siting requirements to provide attenuation capacity for waste constituents that leak or leach from retention ponds or corrals. Similar to Alternative 2, this Alternative includes performance based siting criteria that recommend facilities be underlain by natural geologic materials of sufficient thickness and with appropriate physical and chemical properties to ensure attainment of the applicable performance goal considering waste characteristics, facility design, construction, operation, maintenance, and closure. Also similar to Alternatives 1 and 2 and to conform with the Tulare Lake Basin Plan (CVRWQCB, 1995), this Alternative recommends that retention ponds, corrals, and milk parlors be sited, designed, constructed, and operated to ensure that the contained wastes will be a minimum of five feet above the highest anticipated elevation of underlying ground water.

4.4.2 Design (Containment System)

The recommended minimum criteria for retention ponds are based on NRCS guidelines. These guidelines "...address the design and construction techniques needed to overcome

Final Report

certain soil limitations.” It is noted that the NRCS guidelines are not requirements. Rather, they present guidance to consider during the planning, design, construction, and operation of agricultural waste storage ponds. The NRCS guidelines have been adopted as minimum design standards for confined animal facility waste management by a number of states and local California counties (BVA 2004). The guidelines are included in Part 651 (Agricultural Waste Management Field Handbook) of the National Engineering Handbook that was issued by the USDA in 1992.⁹ The Field Handbook is the USDA’s official guide for adhering to environmental regulations concerning animal waste and provides specific information regarding waste management system design. The most significant of the Field Handbook guidelines pertaining to groundwater protection are included in Chapter 7: Geologic and Ground Water Considerations (NRCS 1999), Chapter 10: Agricultural Waste Management System Component Design (NRCS 1996), and Appendix 10D: Geotechnical, Design, and Construction Guidelines (NRCS 1997). The proposed standards and associated rationale and justification for the recommendations are summarized in Table 4-4.

The NRCS guidelines acknowledge that using a permeability requirement alone ignores other factors such as liner thickness and head acting on the liner system that control seepage from an impoundment. Criteria based on a seepage rate will allow more design flexibility and better protection of groundwater than criteria based on permeability. In designing a liner to meet a seepage rate criterion, the liner thickness, permeability, and head on the liner can be varied to achieve the most economical design considering the site conditions.

For this Alternative, it is recommended that retention pond design follows NRCS guidelines. NRCS guidelines suggest that given a specific seepage rate, the required liner thickness of the clay liner can be determined using test values for permeability and the depth of wastewater in the retention pond. Alternatively, given a specific discharge rate, the minimum liner permeability could be determined using an assumed liner thickness as specified on page 10D-7 of Appendix D of the NRCS guidelines. Because some studies have shown that manure sealing may be compromised by the drying of the liner when the pond levels drop or during solids removal from the pond, allowing credit for manure sealing may be unconservative and is not recommended. As a minimum, we recommend the retention pond design include either a compacted clay liner with a maximum seepage rate of 1×10^{-6} cm/sec, without the crediting of manure sealing, or alternative liner types which provide equal or lower seepage rates. We also recommend including a layer of operations soil at least 2 feet thick that does not include angular rock fragments or other materials that may damage the underlying liner. Depending upon the types of granular or native materials employed at the specific site, geosynthetic cushion materials may be necessary to protect the liner from damage from the operations layer.

NRCS does not contain guidelines specific to corrals and groundwater protection. However, the Kings County (2002) Animal Confinement Ordinance requires that clay soils (not less than 20 percent clay and silt) shall underlie the corrals and dry manure storage areas. This

⁹ The Agricultural Waste Management Field Handbook was originally issued by the US Department of Agriculture Soil Conservation Service (SCS) in 1992. The SCS became the Natural Resources Conservation Service (NRCS) in 1994.

criteria is adopted for this Alternative because clayey material will act to attenuate chemical constituents and limit their potential to reach the groundwater. The clay must be compacted to 90 percent relative compaction to form a layer at least one foot thick. The 20 percent (minimum) silt and clay layer should be covered with a sufficient thickness of soil to provide protection from damage from animals contained within the corral. We recommend having a layer of operations soil at least 2 feet thick that does not include angular rock fragments or other materials that may damage the underlying liner. Depending upon the types of granular or native materials employed at the specific site, geosynthetic cushion materials may be necessary to protect the liner from damage from the operations layer. This Alternative also includes sloping requirements consistent with CCR Title 3, Division 2, Chapter 1, Article 22 (described in Section 4.2.2).

This Alternative requires that the milk parlor be designed in accordance with CCR Title 3, Division 2, Chapter 1, Article 2.2. This should minimize the potential for waste migration to the subsurface and to efficiently drain washwater from the milk parlor after use.

4.4.3 Construction Quality Assurance

The importance of good CQA procedures is demonstrated by Bonaparte et al. (2002) who show that leakage through synthetic liner systems can be highly variable depending on the installation procedures. Similar to Alternatives 1 and 2, this Alternative criteria requires retention pond and corral liner construction to be carried out in accordance with a CQA plan certified by an appropriately registered professional to satisfy the requirements currently specified in CCR Title 27 §20324. This Alternative also requires concrete flooring and gutter construction in milk parlors to be tested to ensure conformance with the material specifications.

4.4.4 Operations and Maintenance

Routine inspections and maintenance represent best management practices to ensure that the containment systems continue to function as designed. Accordingly, this Alternative includes weekly inspections to observe the integrity of the containment systems for retention ponds, corrals, and milk parlors. The Alternative also includes regular and timely maintenance to address and correct any deficiencies noted during the inspections. Maintenance criteria also includes maintaining the required retention pond freeboard, filling of depressions in the corral, correction of cracks or defects in the concrete floor in the milk parlor, annual removal of manure and solids from the retention pond, and semi-annual removal for manure from corral areas. These activities are justified to reduce potential contaminant loading to the subsurface. An Operations and Maintenance Plan should be prepared that includes procedures for cleaning out the retention pond and corral without damaging the underlying liners.

4.4.5 Monitoring

Groundwater and vadose zone monitoring is recommended as part of this Alternative. Groundwater and vadose monitoring is justified to provide a means to assess whether the retention pond or corral is meeting its overall objective of no exceedances of water quality



objectives. Background monitoring is necessary to determine if a release to groundwater has occurred. Specific data are not available to assess the potential for groundwater impacts resulting solely from milk parlor wastes. However, it is reasonable to assume that the potential for groundwater impacts from these wastes is sufficiently remote that specific monitoring is not required assuming design, construction, operations, maintenance, and closure in accordance with the requirements of this Alternative.

4.4.6 Closure

This criteria assumes retention pond and corral closure will include removal of the waste materials and lining systems and subsurface testing of the underlying soil for major ions to a depth of 10 feet (minimum) below the base of the retention pond or corral for the reasons described previously. In the event a significant amount of waste materials are indicated, closure should include excavation and disposal of the affected soil or insitu treatment to render the compounds immobile. Excavation and disposal or insitu treatment is justified based on data that indicate: (1) in the presence of oxygen, some of the compounds bound to the soil can transform to more mobile forms and migrate to the groundwater; and (2) comparative numerical modeling performed for this study shows the conservative compounds will ultimately impact groundwater at some level.

Evaluation of Alternative Confined Animal Facilities Criteria

Table 4-2

SUMMARY OF ALTERNATIVE 1 MINIMUM CRITERIA AND BPTC TO APPROACH A NO RELEASE TO UNDERLYING GEOLOGIC MATERIALS PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
Performance	Retention Pond	No release to underlying geologic materials	This performance goal may be necessary for a facility where the underlying geologic materials do not have sufficient physico-chemical properties to attenuate any constituents of concern that may be released and/or the existing groundwater is already polluted with these constituents of concern.
	Corral	No release to underlying geologic materials	
	Milk Parlor	No release to underlying geology materials	
Siting (Separation from Groundwater)	Retention pond	A minimum of 5 ft above the highest anticipated groundwater elevation	Published data (e.g. Ham and DeSutter, 2000; Maule' and Fonstad, 2000) and the modeling performed for this study show that the depth to groundwater is a critical factor in limiting potential impacts to groundwater. However, there is great uncertainty in what separation from groundwater is protective of groundwater quality. A five foot separation is a minimum requirement which is used in the Tulare Lake Basin Plan and also in CCR Title 27 for other types of waste management units. It will be the responsibility of each facility owner to demonstrate that the criteria represent BPTC and are sufficient to meet the performance goal in order to comply with the State's Antidegradation Policy.
	Corral	A minimum of 5 ft above the highest anticipated groundwater elevation	
	Milk Parlor	A minimum of 5 ft above the highest anticipated groundwater elevation	Little data are currently available regarding groundwater impacts associated with leakage from milk parlors and the potential for significant leakage appears to be limited assuming construction in accordance with current regulations and the minimum standards recommended below. It is reasonable to assume, however, that depth to groundwater would have the same significance towards reducing groundwater impacts as for retention ponds and corral areas.
Siting (Geologic Materials)	Retention Pond	Not required	Specific material property criteria are not required because the containment systems (described below) include generally impermeable materials, redundancy, and strict CQA procedures and testing intended to prevent a release to the underlying geologic materials.
	Corral		
	Milk Parlor		

Table 4-2

SUMMARY OF ALTERNATIVE 1 MINIMUM CRITERIA AND BPTC TO APPROACH A NO RELEASE TO UNDERLYING GEOLOGIC MATERIALS PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
Design	Retention Pond	<p>1. The containment system shall be double lined.</p> <p>2. The double liner system shall include an intermediate leachate collection and removal system (LCRS). This layer may be constructed of geosynthetic or natural materials and designed to detect and convey the maximum anticipated leakage from the primary liner. The RWQCB does not approve the use of geosynthetic materials for the leachate collection system due to problems associated with biological clogging. An intermediate leachate collection and removal system should be of sufficient thickness and permeability to effectively remove fluid that may leak through the primary liner. At a minimum, if granular materials are used we recommend a sand layer of two inches be used. The primary criterion for the thickness of sand is the ability to control the thickness during placement. The recommended permeability for sand is 1×10^{-3} cm/sec. Depending upon the types of granular or native materials employed at the specific site, geosynthetic cushion materials may be necessary to protect the liner from damage from the operations layer.</p> <p>3. The primary liner system shall consist of a geomembrane (GM) that shall have appropriate chemical and physical properties to ensure that they do not fail to contain waste because of pressure gradients (including hydraulic head and external hydrogeologic forces), physical contact with the waste, chemical reactions with soil and rock, climatic conditions, the stress of installation, or because of the stress of daily operation. All GMs shall meet the thickness</p>	<p>1. Redundancy through a secondary liner is warranted because data (Bonaparte et al., 2002) suggest that some amount of leakage is likely to occur through geomembranes even when constructed with strict CQA procedures and modeling performed for this investigation indicates that conservative compounds will ultimately reach the groundwater even at very low leakage rates. A secondary liner will provide the redundancy to contain fluid that leaks through the primary liner.</p> <p>2. Data show that even well-constructed GM liners leak a small amount. Bonaparte et al. (2002) report leakage rates for geomembranes that can range from a low value of about 0.2 gpad to a high value of about 21 gpad to account for good to poor construction quality, respectively. The purpose of the intermediate LRCS is to allow monitoring of the primary liner (i.e., to identify whether, and to what extent, leakage is occurring through the primary liner) and to provide a mechanism for removing liquids that enter this system. This system will allow the detection of leaks, removal of fluid that may leak through the primary liner, and repairs to be implemented. Per the CVRWQCB directive, geosynthetic materials may not be used of the leachate collection system.</p> <p>3. Modeling performed for this study shows limiting seepage significantly reduces the potential for groundwater impacts. GMs are essentially impermeable although leakage may occur through holes or defects that can be minimized through strict CQA procedures. The principal mechanism for liquid or gas mass transfer through an intact GM is one of molecular diffusion and diffusion rates for water are extremely low (about 0.020 g/m²/day for 1.0-mm thick HDPE; Bonaparte et al. [2002]). Data (Bonaparte et al. 2002) show that properly constructed GM systems are frequently more than 99 percent efficient and buried HDPE GM liners have an estimated service life that is measured in terms of at least hundreds of years.</p> <p>4. A composite secondary liner provides BPTC to meet the criteria because both theoretical investigations and field performance studies have shown that leakage through composite liners is much less than leakage through GMs alone or soil liners alone (due to their superior performance capabilities, in comparison to GMs, CCLs, or GCLs alone, composite liners have been incorporated into federal minimum requirements for both MSW and hazardous waste landfills (Bonaparte et al. 2002). The basic premise of using a composite liner is that leakage through a hole or defect in the GM is impeded by the presence of the CCL or GCL. If a CCL or GCL is used alone, liquid migration can occur over the entire area of the liner that is subject to a hydraulic head. If a GM is used alone and is placed on a permeable substrate, the rate of flow through a hole in the GM can approach the rate of flow through a similarly-sized orifice. In a composite liner, leakage will only occur at the location of the GM hole, but it will be much slower than flow through an orifice due to the hydraulic impedance provided by the CCL or GCL. Leakage through a secondary GM liner is expected to be very low for the reasons described above and because the loading rate would be limited to the very small amount of fluid that may leak through small holes or defects in the primary GM. Any fluid that does migrate through the secondary GM would then be attenuated by the underlying CCL or GCL. Ham and DeSutter (2000) and NRCS (1997) note that a number of animal waste constituents (e.g. nitrogen compounds and salts) may be fixed or filtered by a GCL or CCL liner.</p>

Table 4-2

SUMMARY OF ALTERNATIVE 1 MINIMUM CRITERIA AND BPTC TO APPROACH A NO RELEASE TO UNDERLYING GEOLOGIC MATERIALS PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
		<p>requirements specified in SWRCB Resolution 93-62 (see footnote 8).</p> <p>4. The secondary liner system shall consist of a composite GM/compacted clay liner (CCL) or composite GM/geosynthetic clay liner (GCL). The CCL shall be two feet thick (min) and shall have a permeability of 1×10^{-7} cm/sec or less. Pursuant to SWRCB requirements, HDPE GMs shall be at least 60-mil thick or if not HDPE, the GM could be 40-mil thick.</p> <p>5. A 2-foot thick operations layer consisting of local natural material over the retention pond liner.</p>	



Table 4-2 SUMMARY OF ALTERNATIVE 1 MINIMUM CRITERIA AND BPTC TO APPROACH A <u>NO RELEASE TO UNDERLYING GEOLOGIC MATERIALS</u> PERFORMANCE GOAL			
STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
	Corral	<p>1. The corral area shall be underlain by a composite liner system that is protected from damage and graded to the slope requirements of CCR Title 3, Division 2, Chapter 1, Article 22.2. The composite liner system shall consist of a composite GM/CCL or composite GM/GCL. GMs shall meet the thickness requirements of SWRCB Resolution 93-62 (see footnote 8). If a CCL is used it shall be a minimum of two feet thick and have a permeability of 1×10^{-7} cm/sec or less. GCLs shall have a permeability of 1×10^{-9} cm/sec or less. Liner systems shall be protected by a layer of operations layer soil 2 feet thick to protect underlying materials from damage.</p>	<p>1. No release to the underlying geologic materials requires that the corral include an essentially impermeable containment system. A composite liner provides BPTC to approach the criteria because the combination of two or more components has proven to be most effective in terms of liquid containment as described above. A double liner system is not warranted because the head acting to leach constituents from a corral area is limited and transient. The sloping requirements will also ensure that no ponding will occur on the corral surface.</p>

Evaluation of Alternative Confined Animal Facilities Criteria

Table 4-2

SUMMARY OF ALTERNATIVE 1 MINIMUM CRITERIA AND BPTC TO APPROACH A NO RELEASE TO UNDERLYING GEOLOGIC MATERIALS PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
	Milk Parlor	<p>1. Milk parlors shall be underlain by a redundant containment system that includes a concrete sealant, concrete flooring, and an underlying barrier layer.</p> <p>2. Concrete flooring shall be constructed to meet the requirements specified by CCR Title 3, Division 2, Chapter 1, Article 22.</p> <p>3. Concrete flooring and contiguous gutters shall be sealed.</p> <p>4. The concrete flooring shall be underlain by a GM that meets the thickness requirements of SWRCB Resolution 93-62 (see footnote 8) and that has appropriate chemical and physical properties to ensure that they do not fail to contain waste because of pressure gradients (including hydraulic head and external hydrogeologic forces), physical contact with the waste, chemical reactions with soil and rock, climatic conditions, the stress of installation, or because of the stress of daily operation.</p>	<p>1. No release to the underlying geologic materials requires that the floor of the milk parlor be essentially impermeable and that it does not contain any cracks or defects that would allow fluid to leak through and contact the underlying geologic material. Redundant containment is justified because intact concrete has a finite (though typically low) permeability that depends largely on the concrete mixture (Ozyildirim, 1998). Concrete is also subject to cracking and data (Aldea et al. 2000) show the permeability of concrete is significantly increased by cracking.</p> <p>2. CCR Title 3, Division 2, Chapter 1, Article 22 requires concrete flooring be guttered and sloped to drain. These standards are justified to minimize the potential for waste migration to the subsurface and to efficiently drain washwater from the milk parlor after use.</p> <p>3. A waterproof sealant is warranted to limit infiltration of the concrete and to minimize the potential of flow to small cracks in the concrete.</p> <p>4. An underlying GM is warranted to prevent contact of washwater that leaks through the concrete from contacting the underlying geologic materials</p>
Construction	Retention Pond	1. All liner construction shall be in accordance with strict CQA procedures that address at minimum the CQA requirements included in	1. Formal CQA in accordance with established procedures is warranted to ensure that containment systems are installed in accordance with the plans and specifications for the project and that the potential for leakage is limited to the greatest extent practicable. Data show that GM (HDPE) liners constructed without a formal CQA
	Corral		



Table 4-2

SUMMARY OF ALTERNATIVE 1 MINIMUM CRITERIA AND BPTC TO APPROACH A NO RELEASE TO UNDERLYING GEOLOGIC MATERIALS PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
	Milk Parlor	<p>CCR Title 27 §20324.</p> <p>2. Installed GM liners shall be tested after installation with an electronic leak detection survey.</p>	<p>program exhibited average monthly leakage rates that are about one to two orders of magnitude greater than flow rates for liners constructed with CQA. Bonaparte et al. (2002) provides data that show average monthly leakage through GM/GCL composites constructed with CQA will often be less than 2 liters per hectare per day (lphd), but occasionally in excess of 10 lphd.</p> <p>2. Implementation of an electronic leak detection after installation of GM liners represents BPTC because data (Bonaparte et al., 2002) show that leakage from single primary GM liner systems constructed with CQA but without electrical leak location surveys will often be less than 50 lphd, but occasionally in excess of 200 lphd. Ham and DeSutter (2000) note performance based testing will provide additional incentives for engineers and contractors to maintain quality control throughout the design and construction phases.</p>
Operation	Retention Pond	<p>The retention pond and all visible portions of exposed liner systems should be inspected weekly until all free liquid is removed from the surface impoundment as part of closure. If, during the active life of the impoundment, the wastes are removed and the bottom of the impoundment is cleaned down to the liner, an inspection should be made of the liner prior to refilling of the impoundment. Retention ponds and settling basins shall be visually inspected for: seepage, erosion, vegetation, animal access, rodent damage, reduced freeboard, and liner damage.</p>	<p>Routine inspections represent best management practices to ensure that the containment system continues to function as designed.</p>

Evaluation of Alternative Confined Animal Facilities Criteria

Table 4-2

SUMMARY OF ALTERNATIVE 1 MINIMUM CRITERIA AND BPTC TO APPROACH A NO RELEASE TO UNDERLYING GEOLOGIC MATERIALS PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
	Corral	All visible portions of the containment system should be inspected weekly until the corral is removed from service and closed. The corrals shall be inspected daily for ponding. If, during the active life of the corral, the wastes are removed and the corral is cleaned down to the low permeability layer, an inspection should be made of the liner prior to reuse of the corral.	
	Milk Parlor	Concrete floors and any other constructed structures that will act to contain, store, or convey milking parlor wastes should be inspected weekly for cracking and proper drainage.	
Maintenance	Retention Pond	Any deficiencies found as a result of the visual inspections shall be expeditiously corrected. The retention ponds shall be maintained so that the integrity of the seal is ensured. Manure and solids shall be removed at least once per year or at a frequency sufficient to maintain minimum freeboard requirements at all times	Routine maintenance represent best management practices to ensure that the containment system continues to function as designed.
	Corral	Manure shall be removed from corrals at least two times per year (Spring and Fall). Regular maintenance of corrals shall include filling of depressions. Care shall be taken not to disturb the manure pack/seal layer and the underlying liner systems in the corrals	
	Milk Parlor	Cracks or defects observed during monitoring in concrete floors and any other constructed structures that will act to contain, store, or convey milking parlor wastes shall be expeditiously corrected.	



Table 4-2

SUMMARY OF ALTERNATIVE 1 MINIMUM CRITERIA AND BPTC TO APPROACH A NO RELEASE TO UNDERLYING GEOLOGIC MATERIALS PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
Groundwater Monitoring	Retention Pond	The groundwater monitoring program should include: (1) a sufficient number of background monitoring points installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that represent the quality of groundwater that has not been affected by a release from the retention pond or corral; (2) a sufficient number of monitoring points installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer downgradient of the retention pond and corral and to allow for the detection of a release from the basin or corral.	Groundwater monitoring is justified to provide a means to assess whether the retention pond or corral is meeting its overall objective of no release to the underlying geologic materials. Background monitoring is necessary to determine if a release to groundwater has occurred.
	Corral		
	Milk Parlor	Not required	Specific data are not available to assess the potential for groundwater impacts resulting solely from milk parlor wastes. However, it is reasonable to assume that the potential for groundwater impacts from these wastes is sufficiently remote that specific monitoring is not required assuming construction, operations, maintenance, and closure in substantial accordance with the requirements of this Alternative.
Vadose Zone Monitoring	Retention Pond	Vadose zone monitoring should include: (1) a sufficient number of background monitoring points established at appropriate locations and depths to yield soil pore liquid samples or soil pore liquid measurements that represent the quality of soil pore liquid that has not been affected by a release from the retention pond or corral; and (2) a sufficient number of monitoring points established at appropriate locations and depths to yield soil pore liquid samples or soil pore liquid measurements that provide the best assurance of the earliest possible detection of a release from the basin or corral.	Vadose zone monitoring is justified to provide a means to assess whether the retention pond or corral is meeting its overall objective of no release to the underlying geologic materials. Background monitoring is necessary to determine if a release to groundwater has occurred.
	Corral		

Evaluation of Alternative Confined Animal Facilities Criteria

Table 4-2

SUMMARY OF ALTERNATIVE 1 MINIMUM CRITERIA AND BPTC TO APPROACH A NO RELEASE TO UNDERLYING GEOLOGIC MATERIALS PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
	Milk Parlor	Not required	Specific data are not available to assess the potential for impacts to the vadose zone resulting solely from milk parlor wastes. However, it is reasonable to assume that the potential leakage to the vadose zone from these wastes is sufficiently remote that specific monitoring is not required assuming construction, operations, maintenance, and closure in substantial accordance with the requirements of this Alternative.
Closure	Retention Pond	1. Closure will include removal of the solid and liquid waste and any underlying constructed lining systems.	1. Solid and liquid wastes in the retention ponds and corrals represent contaminant sources. Therefore, removal of these materials represents BPTC to eliminate future input loading to the subsurface.
	Corral	2. Subsurface soils shall be tested for major ions to a depth of 10 feet (minimum) below the base of the basin or corral. Deeper soil testing may be necessary if testing indicates constituents of concern are present at elevated levels at 10 feet below the base of the retention pond or corral. 3. In the event a significant amount of waste materials are indicated, closure should include excavation and removal of the affected soil or insitu treatment to ensure that the detected contaminants do not pose a risk to groundwater quality.	2. Data (Maule' and Fonstad, 2000; Sweeten, undated; Ham and DeSutter, 2000) show that the greatest risk to groundwater contamination may occur when a retention pond or corral is closed or removed from service because a significant amount of nitrogen and salt compounds can build up in the soil under these facilities even with low leakage rates. The available data (Ham and DeSutter 2000, Sweeten, undated) show that these bound constituents are usually confined to the upper 3 m below the retention pond or corral. Therefore, subsurface testing to a minimum depth of 10 feet below the base of the basin or corral represents BPTC to assess whether these contaminants are present and to provide the information necessary to implement remediation if necessary. 3. The data referenced above indicate that in the presence of oxygen, some of the compounds bound to the soil can transform to more mobile forms and migrate to the groundwater. Comparative numerical modeling performed for this study shows the conservative compounds will ultimately impact groundwater at some level. Removal or insitu treatment of these compounds to render them permanently immobile represents BPTC.
	Milk Parlor	None required unless operating record shows evidence of significant leakage. Soil testing to a minimum of 10 feet below the base of milk parlors is necessary if there is evidence of significant leakage.	Little data are available to assess leakage from milk parlors. However, it is reasonable to assume that little leakage will occur due to the transient nature of waste loading and the fact that milk parlor floors constructed under this standard will be relatively impermeable, sloped to drain, and underlain by a GM liner. Testing to a minimum depth of 10 feet represents BPTC for the reasons described above if the operating record indicates evidence of significant leakage.



Evaluation of Alternative Confined Animal Facilities Criteria

Table 4-3

SUMMARY OF ALTERNATIVE 2 MINIMUM CRITERIA AND BPTC TO APPROACH A NO CHANGE IN GROUNDWATER QUALITY PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
Performance	Retention Pond	No change in groundwater quality	This performance goal may be applicable where the underlying geologic materials have sufficient physico-chemical properties to attenuate any constituents of concern that may be released and the underlying groundwater is deep and has assimilative capacity, or for a discharger who cannot demonstrate that any change in high quality groundwater will be consistent with the maximum benefit to the people of the State
	Corral		
	Milk Parlor		
Siting (Separation from Groundwater)	Retention Pond	A minimum of 5 ft above the highest anticipated groundwater elevation	Published data (e.g. Ham and DeSutter, 2000; Maule' and Fonstad, 2000) and the modeling performed for this study show that the depth to groundwater is a critical factor in limiting potential impacts to groundwater. However, there is great uncertainty in what separation from groundwater is protective of groundwater quality. A five foot separation is a minimum requirement which is used in the Tulare Lake Basin Plan and also in CCR Title 27 for other types of waste management units.
	Corral	A minimum of 5 ft above the highest anticipated groundwater elevation	
	Milk Parlor	A minimum of 5 ft above the highest anticipated groundwater elevation	Little data are currently available regarding groundwater impacts associated with leakage from milk parlors and the potential for significant leakage appears to be limited assuming construction in accordance with current regulations and the minimum standards recommended below. It is reasonable to assume, however, that depth to groundwater would have the same significance towards reducing groundwater impacts as for retention ponds and corral areas.
Siting (Geologic Materials)	Retention Pond	1. Facilities subject to this criteria shall be underlain by natural geologic materials of sufficient thickness and with appropriate physical and chemical properties to ensure attainment of the applicable performance goal considering waste characteristics, facility design, construction, operation, maintenance, and closure	1. Low permeability geologic materials are justified because data (Ham and DeSutter, 2000) show that the presence of clay is one of the most significant factors in limiting groundwater impacts from retention pond seepage. Modeling performed for this study shows that low permeability units significantly increase the amount of time required for contaminants to reach the groundwater.
	Corral		2. Ham and DeSutter (2000) also show that significant reservoirs of nitrogen compounds and salts can build up under retention ponds even assuming low seepage rates. Limiting migration of these compounds is largely a factor of the physical and chemical properties of the subsurface soils (typically as represented by cation exchange capacity).
	Milk Parlor		
Design	Retention Pond	1. The containment system shall include a composite liner system that consists of a GM/CCL or a GM/GCL.	1. No change in groundwater quality requires that the retention pond include an essentially impermeable containment system because modeling shows that conservative contaminants will ultimately reach

Evaluation of Alternative Confined Animal Facilities Criteria

Table 4-3

SUMMARY OF ALTERNATIVE 2 MINIMUM CRITERIA AND BPTC TO APPROACH A NO CHANGE IN GROUNDWATER QUALITY PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
		<p>2. The GM shall have appropriate chemical and physical properties to ensure that they do not fail to contain waste because of pressure gradients (including hydraulic head and external hydrogeologic forces), physical contact with the waste, chemical reactions with soil and rock, climatic conditions, the stress of installation, or because of the stress of daily operation. GMs shall meet the thickness requirements specified in SWRCB Resolution 93-62 (see footnote 8).</p> <p>3. The CCL if used shall be a minimum of two feet thick and have a hydraulic conductivity of 1×10^{-7} cm/sec or less. GCLs shall have a permeability of 1×10^{-9} cm/sec or less. The liner should be protected by a layer of operations soil at least 2 feet thick that does not include angular rock fragments or other materials that may damage the underlying liner. Depending upon the types of granular or native materials employed at the specific site, geosynthetic cushion materials may be necessary to protect the liner from damage from the operations layer.</p>	<p>the groundwater even assuming very low leakage rates. A composite secondary liner provides BPTC to approach the criteria because the combination of two or more components has proven to be most effective in terms of liquid containment. Secondary containment is necessary because a small amount of leakage is known to occur even in well-constructed GM liners (Bonaparte et al. 2002).</p> <p>2. A GM is warranted because intact GMs are essentially impermeable although leakage may occur through holes or defects that can be minimized through strict CQA procedures. Data (Bonaparte et al. 2002) show that properly constructed GM systems are frequently more than 99 percent efficient and buried HDPE GM liners have an estimated service life that is measured in terms of at least hundreds of years.</p> <p>3. A GCL or CCL is warranted to meet the no change in groundwater quality goal because a finite amount of leakage is known to occur through well-constructed GM liners. GCL or CCL materials are justified for secondary containment because of their low hydraulic conductivity and because the clay will filter and attenuate some waste constituents before they reach the underlying geologic materials (Ham and DeSutter, 2000).</p>
	Corral	This Alternative includes a CCL that is at least 1 foot thick and has a hydraulic conductivity of 1×10^{-7} cm/sec or less or a GCL below the corral area. GCLs shall have a permeability of 1×10^{-9} cm/sec or less. The lining system should be protected by a layer of operations soil at least 2 feet thick that does not include angular rock fragments or other materials that may damage the underlying liner. Depending upon the types of granular or native materials employed at the specific site, geosynthetic cushion materials may be necessary to protect the liner from damage from the operations layer. The corrals should be sloped to drain as required in CCR Title 3, Division 2, Chapter 1, Article 22 and to convey the drainage water to an appropriate discharge point or location.	A liner system below the corral area is justified because data (Chang et al., 1973; Adriano et al., 1971; Sweeten, undated; Maule' and Fonstad, 2000) show that nutrients and salts are likely to build up under corral areas even assuming a very low permeability seal is formed at the manure/soil interface. Modeling performed for this study and published data (Adriano et al., 1971) show that these constituents potentially can impact groundwater. CCL or a GCL is justified to act as a chemical trap for ammonium and cations. A low permeability liner system is warranted to minimize infiltration and leaching to the subsurface.
	Milk Parlor	<p>1. The design criteria for this Alternative includes material and drainage requirements specified by CCR Title 3, Division 2, Chapter 1, Article 22.</p> <p>2. The standard also includes that the concrete surface be waterproofed with a sealant to minimize infiltration of wastes and washwater through the concrete.</p>	1. CCR Title 3, Division 2, Chapter 1, Article 22 requires concrete flooring be guttered and sloped to drain. These standards are justified to minimize the potential for waste migration to the subsurface and to efficiently drain washwater from the milk parlor after use.



Table 4-3

SUMMARY OF ALTERNATIVE 2 MINIMUM CRITERIA AND BPTC TO APPROACH A NO CHANGE IN GROUNDWATER QUALITY PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
			2. A waterproof sealant is warranted because intact concrete has a finite (though typically low) permeability that depends largely on the concrete mixture (Ozyildirim, 1998).
Construction	Retention Pond	<p>1. All liner construction shall be in accordance with strict CQA procedures that address at minimum the CQA requirements included in CCR Title 27 §20324.</p> <p>2. Installed GM liners shall be tested after installation with an electronic leak detection survey.</p>	<p>1. Formal CQA in accordance with established procedures is warranted to ensure that containment systems are installed in accordance with the plans and specifications for the project and that the potential for leakage is limited to the greatest extent practicable. Data show that GM (HDPE) liners constructed without a formal CQA program exhibited average monthly leakage rates that are about one to two orders of magnitude greater than flow rates for liners constructed with CQA. Bonaparte et al. (2002) provides data that show average monthly leakage through GM/GCL composites constructed with CQA will often be less than 2 liters per hectare per day (lphd), but occasionally in excess of 10 lphd.</p> <p>2. Implementation of an electronic leak detection after installation of GM liners represents BPTC because data (Bonaparte et al., 2002) show that leakage from single primary GM liner systems constructed with CQA but without electrical leak location surveys will often be less than 50 lphd, but occasionally in excess of 200 lphd. Ham and DeSutter (2000) note performance based testing will provide additional incentives for engineers and contractors to maintain quality control throughout the design and construction phases.</p>
	Corral	1. All liner construction shall be in accordance with strict CQA procedures that address at minimum the CQA requirements included in CCR Title 27 §20324.	CQA of the CCL or GCL is warranted to ensure that maximum permeability requirements (for the CCL) are met and that the GCL meets its applicable performance specifications.
	Milk Parlor	Concrete flooring and gutter construction should be tested to ensure conformance with the material specifications for the project.	This testing is warranted based on best construction practices and to ensure that the concrete meets the material specifications for the project.

Evaluation of Alternative Confined Animal Facilities Criteria

Table 4-3

SUMMARY OF ALTERNATIVE 2 MINIMUM CRITERIA AND BPTC TO APPROACH A NO CHANGE IN GROUNDWATER QUALITY PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
Operation	Retention Pond	The retention pond and all visible portions of exposed liner systems should be inspected weekly until all free liquid is removed from the surface impoundment as part of closure. If, during the active life of the impoundment, the wastes are removed and the bottom of the impoundment is cleaned down to the liner, an inspection should be made of the liner prior to refilling of the impoundment. Retention ponds and settling basins shall be visually inspected for: seepage, erosion, vegetation, animal access, rodent damage, liner damage, and reduced freeboard.	Routine inspections represent best management practices to ensure that the containment system continues to function as designed.
	Corral	All visible portions of the containment system should be inspected weekly until the corral is removed from service and closed. If, during the active life of the corral, the wastes are removed and the corral is cleaned down to the low permeability layer, an inspection should be made of the liner prior to reuse of the corral.	
	Milk Parlor	Concrete floors and any other constructed structures that will act to contain, store, or convey milking parlor wastes should be inspected weekly	
Maintenance	Retention Pond	Any deficiencies found as a result of the visual inspections shall be expeditiously corrected. The retention ponds shall be maintained so that the integrity of the seal is ensured. Manure and solids shall be removed at least once per year or at a frequency sufficient to maintain minimum freeboard requirements at all times	Routine maintenance represent best management practices to ensure that the containment system continues to function as designed
	Corral	Manure shall be removed from corrals at least two times per year (Spring and Fall). Regular maintenance of corrals shall include filling of depressions. Care shall be taken not to disturb the manure pack/seal layer and the underlying liner systems in the corrals	
	Milk Parlor	Cracks or defects observed during monitoring in concrete floors and any other constructed structures that will act to contain, store, or convey milking parlor wastes shall be expeditiously corrected.	
Groundwater Monitoring	Retention pond	The groundwater monitoring program should include: (1) a sufficient number of background monitoring points installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that represent the quality of groundwater that has not been affected by a release from the basin or corral; (2) a sufficient number of monitoring points installed at appropriate locations and depths to yield groundwater samples from the uppermost	Groundwater monitoring is justified to provide a means to assess whether the retention pond or corral is meeting its overall objective of no release to the underlying geologic materials. Background monitoring is necessary to determine if a release to groundwater has occurred.
	Corral		



Table 4-3

SUMMARY OF ALTERNATIVE 2 MINIMUM CRITERIA AND BPTC TO APPROACH A NO CHANGE IN GROUNDWATER QUALITY PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
		aquifer downgradient of the retention pond and corral and to allow for the detection of a release from the basin or corral.	
	Milk Parlor	Not required	Specific data are not available to assess the potential for groundwater impacts resulting solely from milk parlor wastes. However, it is reasonable to assume that the potential for groundwater impacts from these wastes is sufficiently remote that specific monitoring is not required assuming construction, operations, maintenance, and closure in substantial accordance with the requirements of this Alternative.
Vadose Zone Monitoring	Retention Pond	Vadose zone monitoring should include: (1) a sufficient number of background monitoring points established at appropriate locations and depths to yield soil pore liquid samples or soil pore liquid measurements that represent the quality of soil pore liquid that has not been affected by a release from the retention pond or corral; and (2) a sufficient number of monitoring points established at appropriate locations and depths to yield soil pore liquid samples or soil pore liquid measurements that provide the best assurance of the earliest possible detection of a release from the basin or corral.	Vadose zone monitoring is justified to provide a means to assess whether the retention pond or corral is meeting its overall objective of no release to the underlying geologic materials. Background monitoring is necessary to determine if a release has occurred.
	Corral		
	Milk Parlor	Not required	Specific data are not available to assess the potential for impacts to the vadose zone resulting solely from milk parlor wastes. However, it is reasonable to assume that the potential leakage to the vadose zone from these wastes is sufficiently remote that specific monitoring is not required assuming construction, operations, maintenance, and closure in substantial accordance with the requirements of this Alternative.
Closure	Retention pond	<ol style="list-style-type: none"> 1. Closure will include removal of the solid and liquid waste and any underlying constructed lining systems. 2. Subsurface soils shall be tested for major ions to a depth of 10 feet (minimum) below the base of the retention pond or corral. Deeper soil testing may be necessary if testing indicates constituents of concern are present at elevated levels at 10 feet below the base of the retention pond or corral. 3. In the event a significant amount of waste materials are indicated, closure should include excavation and removal of the affected soil or insitu treatment to ensure that the detected contaminants do not pose a risk to groundwater quality. 	<ol style="list-style-type: none"> 1. Solid and liquid wastes in the retention ponds and corrals represent contaminant sources. Therefore, removal of these materials represents BPTC to eliminate future input loading to the subsurface. 2. Data (Maule' and Fonstad, 2000; Sweeten, undated; Ham and DeSutter, 2000) show that the greatest risk to groundwater contamination may occur when a retention pond or corral is closed or removed from service because a significant amount of nitrogen and salt compounds can build up in the soil under these facilities even with low leakage rates. The available data (Ham and DeSutter 2000, Sweeten, undated) show that these bound constituents are usually confined to the upper 3 m below the retention pond or corral. Therefore, subsurface testing to a minimum depth of 10 feet below the
	Corral		

Evaluation of Alternative Confined Animal Facilities Criteria

Table 4-3

SUMMARY OF ALTERNATIVE 2 MINIMUM CRITERIA AND BPTC TO APPROACH A NO CHANGE IN GROUNDWATER QUALITY PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
			<p>base of the retention pond or corral represents BPTC to assess whether these contaminants are present and to provide the information necessary to implement remediation if necessary.</p> <p>3. The data referenced above indicate that in the presence of oxygen, some of the compounds bound to the soil can transform to more mobile forms and migrate to the groundwater. Comparative numerical modeling performed for this study shows the conservative compounds will ultimately impact groundwater at some level. Removal or insitu treatment of these compounds to render them permanently immobile represents BPTC.</p>
	Milk Parlor	None required unless operating record shows evidence of significant leakage. Soil testing to a minimum of 10 feet below the base of milk parlors is necessary if there is evidence of significant leakage.	<p>Little data are available to assess leakage from milk parlors. However, it is reasonable to assume that little leakage will occur due to the transient nature of waste loading and the fact that milk parlor floors constructed under this standard will be relatively impermeable and sloped to drain. Testing to a minimum depth of 10 feet represents BPTC for the reasons described above if the operating record indicates evidence of significant leakage.</p>



Table 4-4
SUMMARY OF ALTERNATIVE 3 MINIMUM CRITERIA AND BPTC TO APPROACH A NO EXCEEDANCES OF WATER QUALITY OBJECTIVES
PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
Performance	Retention Pond	No exceedances of water quality objectives	This performance goal may be applicable where groundwater has assimilative capacity and where the underlying geologic materials have sufficient physico-chemical properties to attenuate any constituents of concern that may be released.
	Corral		
	Milk Parlor		
Siting (Separation from Groundwater)	Retention pond	A minimum of 5 ft above the highest anticipated groundwater elevation	Published data (e.g. Ham and DeSutter, 2000; Maule' and Fonstad, 2000) and the modeling performed for this study show that the depth to groundwater is a critical factor in limiting potential impacts to groundwater. However, there is great uncertainty in what separation from groundwater is protective of groundwater quality. A five foot separation is a minimum requirement which is used in the Tulare Lake Basin Plan and also in CCR Title 27 for other types of waste management units.
	Corral	A minimum of 5 ft above the highest anticipated groundwater elevation	
	Milk Parlor	A minimum of 5 ft above the highest anticipated groundwater elevation	Little data are currently available regarding groundwater impacts associated with leakage from milk parlors and the potential for significant leakage appears to be limited assuming construction in accordance with current regulations and the minimum standards recommended below. It is reasonable to assume, however, that depth to groundwater would have the same significance towards reducing groundwater impacts as for retention ponds and corral areas.
Siting (Geologic Materials)	Retention pond	1. Facilities subject to this standard shall be underlain by natural geologic materials of sufficient thickness and with appropriate physical and chemical properties to ensure attainment of the applicable performance goal considering waste characteristics, facility design, construction, operation, maintenance, and closure.	<p>1. Low permeability geologic materials are justified because data (Ham and DeSutter, 2000) show that the presence of clay is one of the most significant factors in limiting groundwater impacts from retention pond seepage. Modeling performed for this study shows that low permeability units significantly increase the amount of time required for contaminants to reach the groundwater and the contaminant concentrations in the groundwater.</p> <p>2. Ham and DeSutter (2000) also show that significant reservoirs of nitrogen compounds and salts can build up under retention ponds even assuming low seepage rates. Limiting migration of these compounds is largely a factor of the physical and chemical properties of the subsurface soils (typically as represented by cation exchange capacity).</p>
	Corral		
	Milk Parlor		

Evaluation of Alternative Confined Animal Facilities Criteria

Table 4-4
SUMMARY OF ALTERNATIVE 3 MINIMUM CRITERIA AND BPTC TO APPROACH A NO EXCEEDANCES OF WATER QUALITY OBJECTIVES
PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
Design	Retention Pond	<p>It is recommended that retention pond design follows NRCS guidelines. NRCS guidelines suggest that given a specific seepage rate, the required liner thickness of the clay liner can be determined using test values for permeability and the depth of wastewater in the retention pond. Alternatively, given a specific discharge rate, the minimum liner permeability could be determined using an assumed liner thickness as specified on page 10D-7 of Appendix D of the NRCS guidelines.</p> <p>As a minimum, we recommend the retention pond design include either a compacted clay liner with a maximum seepage rate of 1×10^{-6} cm/sec, without the crediting of manure sealing, or alternative liner types which provide equal or lower seepage rates.</p> <p>We also recommend including a layer of operations soil at least 2 feet thick that does not include angular rock fragments or other materials that may damage the underlying liner. Depending upon the types of granular or native materials employed at the specific site, geosynthetic cushion materials may be necessary to protect the liner from damage from the operations layer.</p>	This standard is based on the NRCS guidelines which acknowledge that using only permeability as a criterion ignores other factors (such as liner thickness, permeability, and head on the liner) defining seepage from an impoundment. The NRCS guidelines suggest a maximum seepage rate of 1×10^{-6} cm/sec with no credit for manure sealing.
	Corral	Naturally occurring or imported clayey (not less than 20 percent clay and silt) soils shall underlie the corrals and dry manure storage areas. Imported clay materials shall be placed and compacted to at least 90 percent relative compaction to form a layer at least 1 ft thick (minimum). The 20 percent (minimum) silt and clay layer should be covered with a sufficient thickness of soil to	A liner system below the corral area is justified because data (Chang et al., 1973; Adriano et al., 1971; Sweeten, undated; Maule' and Fonstad, 2000) show that nutrients and salts are likely to build up under corral areas even assuming a very low permeability seal is formed at the manure/soil interface. Modeling performed for this study and published data (Adriano et al., 1971) show that these constituents potentially can impact groundwater. Requiring a minimum clay content and a CCL if appropriately clayey natural geologic materials are not present is justified to act as a chemical trap for ammonium and cations and to reduce infiltration and leaching to the subsurface.



Table 4-4
SUMMARY OF ALTERNATIVE 3 MINIMUM CRITERIA AND BPTC TO APPROACH A NO EXCEEDANCES OF WATER QUALITY OBJECTIVES
PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
		provide protection from damage from animals contained within the corral. The operations soil should be at least 2 feet thick and does not include angular rock fragments or other materials that may damage the underlying liner. Depending upon the types of granular or native materials employed at the specific site, geosynthetic cushion materials may be necessary to protect the liner from damage from the operations layer. Corrals should be sloped to drain and to convey the drainage water to an appropriate discharge point or location in accordance with CCR Title 3, Division 2, Chapter 1, Article 22.	
	Milk Parlor	1. The design standard for this Alternative includes material and drainage requirements specified by CCR Title 3, Division 2, Chapter 1, Article 22.	1. CCR Title 3, Division 2, Chapter 1, Article 22 requires concrete flooring be guttered and sloped to drain. These standards are justified to minimize the potential for waste migration to the subsurface and to efficiently drain washwater from the milk parlor after use.
Construction	Retention Pond	<p>1. All liner construction shall be in accordance with strict CQA procedures that address at minimum the CQA requirements included in CCR Title 27 §20324.</p> <p>2. Installed GM liners shall be tested after installation with an electronic leak detection survey.</p>	<p>1. Formal CQA in accordance with established procedures is warranted to ensure that containment systems are installed in accordance with the plans and specifications for the project and that the potential for leakage is limited to the greatest extent practicable. Data show that GM (HDPE) liners constructed without a formal CQA program exhibited average monthly leakage rates that are about one to two orders of magnitude greater than flow rates for liners constructed with CQA. Bonaparte et al. (2002) provides data that show average monthly leakage through GM/GCL composites constructed with CQA will often be less than 2 liters per hectare per day (lphd), but occasionally in excess of 10 lphd.</p> <p>2. Implementation of an electronic leak detection after installation of GM liners represents BPTC because data (Bonaparte et al., 2002) show that leakage from single primary GM liner systems constructed with CQA but without electrical leak location surveys will often be less than 50 lphd, but occasionally in excess of 200 lphd. Ham and DeSutter (2000) note performance based testing will provide additional incentives for engineers and contractors to maintain quality control throughout the design and construction phases.</p>

Evaluation of Alternative Confined Animal Facilities Criteria

Table 4-4
SUMMARY OF ALTERNATIVE 3 MINIMUM CRITERIA AND BPTC TO APPROACH A NO EXCEEDANCES OF WATER QUALITY OBJECTIVES
PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
	Corral	1. All liner construction shall be in accordance with strict CQA procedures that address at minimum the CQA requirements included in CCR Title 27 §20324.	CQA of the CCL or GCL is warranted to ensure that maximum permeability requirements (for the CCL) are met and that the GCL meets it applicable performance specifications.
	Milk Parlor	Concrete flooring and gutter construction should be tested to ensure conformance with the material specifications for the project.	This testing is warranted based on best construction practices and to ensure that the concrete meets the material specifications for the project.
Operation	Retention Pond	The retention pond and all visible portions of exposed liner systems should be inspected weekly until all free liquid is removed from the surface impoundment as part of closure. If, during the active life of the impoundment, the wastes are removed and the bottom of the impoundment is cleaned down to the liner, an inspection should be made of the liner prior to refilling of the impoundment. Retention ponds and settling basins shall be visually inspected for seepage, erosion, vegetation, animal access, rodent damage, liner damage, and reduced freeboard.	Routine inspections represent best management practices to ensure that the containment system continues to function as designed.
	Corral	All visible portions of the containment system should be inspected weekly until the corral is removed from service and closed. If, during the active life of the corral, the wastes are removed and the corral is cleaned down to the low permeability layer, an inspection should be made of the liner prior to reuse of the corral.	



Table 4-4
SUMMARY OF ALTERNATIVE 3 MINIMUM CRITERIA AND BPTC TO APPROACH A NO EXCEEDANCES OF WATER QUALITY OBJECTIVES
PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
	Milk Parlor	Concrete floors and any other constructed structures that will act to contain, store, or convey milking parlor wastes should be inspected weekly	
Maintenance	Retention Pond	Any deficiencies found as a result of these visual inspections shall be expeditiously corrected. The retention ponds shall be maintained so that the integrity of the seal is ensured. Manure and solids shall be removed at least once per year or at a frequency sufficient to maintain minimum freeboard requirements at all times	Routine maintenance represent best management practices to ensure that the containment system continues to function as designed
	Corral	Manure shall be removed from corrals at least two times per year (Spring and Fall). Regular maintenance of corrals shall include filling of depressions. Care shall be taken not to disturb the manure pack/seal layer and the underlying liner systems in the corrals	
	Milk Parlor	Cracks or defects observed during monitoring in concrete floors and any other constructed structures that will act to contain, store, or convey milking parlor wastes shall be expeditiously corrected (filled, etc.).	
Groundwater Monitoring	Retention Pond	The groundwater monitoring program should include: (1) a sufficient number of background monitoring points installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that represent the quality of groundwater that has not been affected by a	Groundwater monitoring is justified to provide a means to assess whether the retention pond or corral is meeting its overall objective of no release to the underlying geologic materials. Background monitoring is necessary to determine if a release to groundwater has occurred.
	Corral		

Evaluation of Alternative Confined Animal Facilities Criteria

Table 4-4
SUMMARY OF ALTERNATIVE 3 MINIMUM CRITERIA AND BPTC TO APPROACH A NO EXCEEDANCES OF WATER QUALITY OBJECTIVES
PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
		release from the retention pond or corral; (2) a sufficient number of monitoring points installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer downgradient of the retention pond and corral. And to allow for the detection of a release from the retention pond or corral.	
	Milk Parlor	Not required	Specific data are not available to assess the potential for groundwater impacts resulting solely from milk parlor wastes. However, it is reasonable to assume that the potential for groundwater impacts from these wastes is sufficiently remote that specific monitoring is not required assuming construction, operations, maintenance, and closure in substantial accordance with the requirements of this Alternative.
Vadose Zone Monitoring	Retention Pond	Vadose zone monitoring should include: (1) a sufficient number of background monitoring points established at appropriate locations and depths to yield soil pore liquid samples or soil pore liquid measurements that represent the quality of soil pore liquid that has not been affected by a release from the retention pond or corral; and (2) a sufficient number of monitoring points established at appropriate locations and depths to yield soil pore liquid samples or soil pore liquid measurements that provide the best assurance of the earliest possible detection of a release from the retention pond or corral.	Vadose zone monitoring is justified to provide a means to assess whether the retention pond or corral is meeting its overall objective of no release to the underlying geologic materials. Background monitoring is necessary to determine if a release to groundwater has occurred.
	Corral		
	Milk Parlor	Not required	Specific data are not available to assess the potential for impacts to the vadose zone resulting solely from milk parlor wastes. However, it is reasonable to assume that the potential leakage to the vadose zone from these wastes is sufficiently remote that specific monitoring is not required assuming construction, operations, maintenance, and closure in substantial accordance with the requirements of this Alternative.



Table 4-4
SUMMARY OF ALTERNATIVE 3 MINIMUM CRITERIA AND BPTC TO APPROACH A NO EXCEEDANCES OF WATER QUALITY OBJECTIVES PERFORMANCE GOAL

STANDARD	FACILITY	RECOMMENDED CRITERIA	RATIONALE/JUSTIFICATION
Closure	Retention Pond	1. Closure will include removal of the solid and liquid waste and any underlying constructed lining systems.	1. Solid and liquid wastes in the retention ponds and corrals represent contaminant sources. Therefore, removal of these materials represents BPTC to eliminate future input loading to the subsurface.
	Corral	2. Subsurface soils shall be tested for major ions to a depth of 10 feet (minimum) below the base of the retention pond or corral. Deeper soil testing may be necessary if testing indicates constituents of concern are present at elevated levels at 10 feet below the base of the retention pond or corral. 3. In the event a significant amount of waste materials are indicated, closure should include excavation and removal of the affected soil or insitu treatment to ensure that the detected contaminants do not pose a risk to groundwater quality.	2. Data (Maule' and Fonstad, 2000; Sweeten, undated; Ham and DeSutter, 2000) show that the greatest risk to groundwater contamination may occur when a retention pond or corral is closed or removed from service because a significant amount of nitrogen and salt compounds can build up in the soil under these facilities even with low leakage rates. The available data (Ham and DeSutter 2000, Sweeten, undated) show that these bound constituents are usually confined to the upper 3 m below the retention pond or corral. Therefore, subsurface testing to a minimum depth of 10 feet below the base of the retention pond or corral represents BPTC to assess whether these contaminants are present and to provide the information necessary to implement remediation if necessary. 3. The data referenced above indicate that in the presence of oxygen, some of the compounds bound to the soil can transform to more mobile forms and migrate to the groundwater. Comparative numerical modeling performed for this study shows the conservative compounds will ultimately impact groundwater at some level. Removal or insitu treatment of these compounds to render them permanently immobile represents BPTC.
	Milk Parlor	None required unless operating record shows evidence of significant leakage. Soil testing to a minimum of 10 feet below the base of milk parlors is necessary if there is evidence of significant leakage.	Little data are available to assess leakage from milk parlors. However, it is reasonable to assume that little leakage will occur due to the transient nature of waste loading and the fact that milk parlor floors constructed under this standard will be relatively impermeable and sloped to drain. Testing to a minimum depth of 10 feet represents BPTC for the reasons described above if the operating record indicates evidence of significant leakage.

Section 5

Financial Evaluation of Alternatives

All of the Alternatives have costs associated with them. Presented in this section are unit costs for the Alternative elements divided by square feet. For the most part, elements such as liners, sealant costs, etc. were based on known square footage costs (BNI Building News 2003). For elements such as monitoring wells and removal of solids from retention ponds, the square footage was determined from an average of data of dairy facilities provided by the CVRWQCB (the provided data is in Appendix B). The CVRWQCB provided data from 23 random dairies throughout the Central Valley on the number of mature dairy cows at each facility and the square footage of retention ponds, corrals, and milk barns. From the data provided by the CVRWQCB, the average area per cow was estimated for the retention ponds, corrals, and milk barns. These average areas per cow were then used to estimate the average square footage for the retention ponds, corrals, and milk barns at the average-sized dairy (750) cows in the Central Valley. Based on this information, a 750 cow average-sized dairy has 192,401 square feet of retention pond, 563,494 square feet of corral area, and 9,087 square feet of milk barn. As the dairy data has been manipulated into an average, the cost impact to a specific facility will vary. In addition, the costs presented in this report are meant to be a gauge for dairy facilities to evaluate their circumstances. Actual costs can vary depending on facility dimensions, current infrastructure, site specific conditions and market forces.

5.1 Cost Assumptions for Alternatives

Determining the cost of implementing the Alternatives described in Section 4 requires general assumptions. For all of the Alternatives, it was assumed that the operation of a dairy facility is 40 years with an inflation rate of 3 percent per year. All other elements of the cost analysis are dependent on the recommended design, construction, construction quality assurance, maintenance, operations, and closure of the facilities. For all cases, siting of the facilities is not included in the cost estimates.

This analysis assumes that the average dairy facility sizes mentioned above are applicable to all dairies in the Central Valley. For permeability and thickness requirements for the liners, etc., refer to Section 4. As most elements of the Alternatives vary, there are some generalities as to the methods for calculating costs. We assume the following:

- The Construction Quality Assurance (CQA) cost is 10 percent of capital costs, such as the liners. For maintenance of milk production areas, the cost is the sum of the per square foot capital costs divided by the 40 year life-cycle of the facility. As the design requirements identified in the Alternatives vary in degree of strength, so will the costs associated with maintenance
- The placement, replacement, and removal cost of all liners are assumed to be performed by a contractor.

Final Report

- There will be two monitoring wells installed at each of the retention pond and corral, for a total of four monitoring wells per dairy facility. Monitoring well costs assumptions are below, followed by Table 5-1 which is a breakdown for the estimated \$3,947.50 it will cost to install a well.
 - Assume groundwater table occurs 10 ft below ground surface
 - Assume 2-inch diameter monitoring well
 - Assume 10 ft screen interval
 - Assume wells installed under observation of professional engineer/geologist
 - Assume wells installed using hollowstem auger drilling methods
 - Assume well completed at ground surface with protective steel casing
 - Assume 10 hours required to install and develop well
 - Assume local well driller (2 hours travel/mobilization time)
 - Assume 4 hours using Drill Rig for well development
 - Assume permit costs of \$150 for each well installed¹⁰

Table 5-1 Well Installation Costs				
ITEM	UNITS	UNIT RATE OR COST	NO. OF UNITS	ITEM COST
Field Geologist	hours	\$ 90.00	10	\$ 900.00
Field Vehicle	day	\$ 75.00	1	\$ 75.00
Misc. Field Supplies	day	\$ 50.00	1	\$ 50.00
Truck Mounted 2WD Drill Rig	hours	\$ 140.00	12	\$ 1,680.00
Drill Rig well development	hours	\$ 140.00	4	\$ 560.00
Support Vehicle	day	\$ 125.00	1	\$ 125.00
2-in blank PVC	feet	\$ 2.50	15	\$ 37.50
2-in screen PVC	feet	\$ 3.00	10	\$ 30.00
2-in end plug (threaded)	each	\$ 10.00	1	\$ 10.00
2-in slip cap	each	\$ 2.00	1	\$ 2.00
2-in centralizers	each	\$ 22.00	2	\$ 44.00
6-in steel monument	each	\$ 135.00	1	\$ 135.00
Bentonite pellets	sack	\$ 45.00	1	\$ 45.00
Sand (standard grade)	sack	\$ 11.00	4	\$ 44.00
Cement	sack	\$ 10.00	6	\$ 60.00
Permit	each	\$ 150.00	1	\$ 150.00
TOTAL COST				\$ 3,947.50

¹⁰ Permitting costs vary by county.

Evaluation of Alternative Confined Animal Facilities Criteria

- There will be testing for groundwater contamination quarterly for the first year and semi-annually thereafter. See Table 5-2 for tested elements and cost.
- Soil testing costs are \$140 due to the equipment needed to collect the samples at a rate of \$40 per hour with approximately 4 samples to be obtained per hour. The cost of the engineer to operate the equipment at a rate of \$100 per hour. Therefore, to obtain the four samples to be analyzed the cost for collecting the samples is estimated to be approximately \$140.
- There will be vadose zone monitoring quarterly the first year and semi-annually thereafter with two samples taken around both the corrals and retention ponds for a total of four samples taken each time. Sampling costs \$75 and laboratory costs \$100 per monitoring point. The sampling cost assumes (1) the field crew is already onsite [i.e., separate mobilization not required]; and (2) the monitoring point may be sampled in 1/2 to 1 hour and may be coordinated with other sampling activities. The laboratory costs may be high because it frequently is not possible to collect sufficient fluid sample volume to run all the analyses.
- The corrals will have the solids (source) removed twice a year.
- There will be testing for soil contamination at closure of the facilities. See Table 5-2 for the tested elements and the cost
 - It is assumed that testing of the facilities will occur with 2-3 samples per acre. Based on dairy averages, retention ponds will have 10 samples taken and corrals will have 26 samples taken each time.
 - It is assumed that each sample taken costs \$140 for laboratory analysis.
 - If test results come back positive for the tested elements, then the retention pond and corral will have two and three feet of soil, respectively, removed and maintained on-site to prevent migration of contaminants.

Table 5-2 Laboratory Testing Costs			
TESTS	SAMPLING COST (per well)	LABORATORY COST (per test)	TOTAL COST
Major Ions in Soil (Alkalinity, B, Ca, Cl, EC, Mg, NO ₃ , % Solids, pH, K, Na, SO ₄)	\$140.00	\$140.00	\$280.00
Major Ions in Groundwater (Alkalinity, Ca, Cl, EC, Mg, NO ₃ , pH, K, Na, SO ₄)	\$150.00	\$100.00	\$250.00

5.1.1 Alternative 1 Costs

As discussed in Section 4, Alternative 1 is the most robust of the three Alternatives and therefore has higher capital costs than the rest. Although the capital costs are higher, the infrastructure is designed to protect the groundwater which lowers the closure costs of



removing soil since contamination is not likely to occur. The main distinction for this Alternative is that the liner assumed to be used in the retention pond is consistent with Title 27 Class II facilities. As such, the capital cost is higher than the other proposed Alternatives. As mentioned previously, there is no liner that will prevent leakage. However, the use of liners in this Alternative is the best practicable technology to attempt to achieve “no release”. The details of the costs for this Alternative are presented in Table 5-3.

5.1.2 Alternative 2 Costs

This Alternative consists of using liners (CCL or GCL) and maintenance operations to reduce infiltration of contaminants into the groundwater. The main differences from Alternative 1 are that a liner is used on the retention pond that is consistent with Class III landfill facility designs, and the corral liner is either a compacted or geosynthetic clay liner. Therefore, the capital costs associated with this design is also less. This Alternative is designed to achieve the performance goal of no change in groundwater quality. The details of the costs for this Alternative are presented in Table 5-4.

5.1.3 Alternative 3 Costs

This Alternative consists of using minimum NRCS guidelines to protect groundwater. As these are minimum criteria, there is a potential for soil contamination which will require removal of approximately four feet of soil combined from the retention ponds and corrals. As such, the cost to implement closure is more expensive than the other Alternatives which have liners. This Alternative is designed to achieve the performance goal of no exceedances of water quality objectives. The details of the costs for this Alternative are presented in Table 5-5.

Evaluation of Alternative Confined Animal Facilities Criteria

Table 5-3 Summary of Costs for Alternative 1

Items		Cost/SF
A Retention Ponds		
Capital Costs	1 Primary liner consistent with Title 27 Class II Surface Impoundments GM (40-mils thick synthetic liner or at least 60-mils thick if the liner consists of HPDE)	\$0.50
	Leachate Collection and Removal System Layer	\$0.50
	Leachate Collection and Removal System: Sumps and Pumps (\$20,000 for 2 sumps & 2 pumps)	\$0.10
	Second composite liner over GM/Compacted Clay Liner @ 1x10-7 cm/sec (at least 2 ft thick) or a GM/GCL @ 1x10-9 cm/sec	\$1.00
	2 Two foot minimum operations layer (local natural material) \$2/CY (geosynthetic cushion assumed not necessary)	\$0.15
	3 CQA Procedures (10% of capital costs)	\$0.12
	4 Install Groundwater Monitoring Wells (2 wells @ \$3,947.50 each)	\$0.04
Operational Costs	5 Annual Maintenance	
	Removal of solids/contaminant source (2 ft) (Assume no additional costs since it is already necessary as a part of normal operations and maintenance.)	\$0.00
	6 Monitor of Groundwater wells (2 well samples and testing @\$250 each)	\$0.01
Closure Costs	7 Monitor of Vadose Zone (2 samples & lab testing @ \$175 each)	\$0.01
	8 Closure	
	Removal of Liner (\$4/CY)	\$0.30
	Subliner soil removal: evaluate major ions concentrations in soil and excavate (not necessary if geosynthetic lined or no evidence of leakage). Removal of 2 ft of soil below retention pond. (Assumed not necessary.)	\$0.00
	9 Closure Testing (Soil testing for major ions: 4.4 acres with 2-3 samples/acre=10 samples and tests @ \$280 each)	\$0.01
B Corrals		
		Cost/SF
Capital Costs	1 Composite liner: low permeability barrier layer consistent with retention pond secondary composite system. GM/Compacted Clay Liner @ 1x10-7 cm/sec (at least 2 ft thick) or a GM/GCL @ 1x10-9 cm/sec	\$1.00
	2 CQA Testing during installation of low permeability layer (10% of capital costs)	\$0.12
	3 Two foot minimum operations layer (local natural material) (geosynthetic cushion assumed not necessary)	\$0.15
	4 Install Groundwater Monitoring Wells (2 wells @\$3,947.50 each)	\$0.02
Operational Costs	5 Remove manure (source) two times a year @\$3 per CY (2 ft)	\$0.11
	6 Monitor of Groundwater wells (2 wells @\$250 each)	\$0.01
	7 Monitor of Vadose Zone (2 samples & lab testing @ \$175 each)	\$0.01
Closure Costs	8 Closure	
	Removal of operations layer/manure (2 ft layer @ \$3 per CY)	\$0.22
	Test soil for major ions content (13 acres with 2 samples/acre=26 samples and tests @ \$280 each)	\$0.02
	(If concentrations represent a threat to groundwater, excavate 2 ft of below operations/manure layer) Assumed not necessary.	\$0.00
C Milk Parlors		
		Cost/SF
Capital Costs	GM (40-mils thick synthetic liner or at least 60-mils thick if the liner consists of HPDE) Cost reflects the material cost plus the complexity of installing the material in milk parlors	\$0.75
	Concrete water-proof surface treatment (2 coats)	\$1.01
	2 CQA testing of concrete during installation (10% of capital costs)	\$0.18
Operational Costs	3 Annual Maintenance to fill cracks and Inspection of concrete surface (Annual concrete slab cost of \$0.05 plus the capital costs divided by 40 years of operation)	\$0.10
Closure Costs	4 No closure costs.	\$0.00



Final Report

Table 5-4 Summary of Costs for Alternative 2

Items		Cost/SF
A Retention Ponds		
Capital Costs	1 Composite Liner	
	GM over GCL or Compacted Clay Layer (\$1/SF)	\$1.00
	2 Two foot minimum operations layer (local natural material) \$2/CY (geosynthetic cushion assumed not necessary)	\$0.15
	3 CQA Procedures (10% of capital costs)	\$0.12
	4 Install Groundwater Monitoring Wells (2 wells @\$3,947.50 each)	\$0.04
Operational Costs	5 Annual Maintenance	
	Removal of solids/contaminant source (2 ft) (Assume no additional costs since it is already necessary as a part of normal operations and maintenance.)	\$0.00
	6 Monitor of Groundwater wells (2 wells @\$250 each)	\$0.01
Closure Costs	7 Monitor of Vadose Zone (2 samples & lab testing @ \$175 each)	\$0.01
	8 Closure	
	Removal of Liner (\$4/CY)	\$0.30
	Subliner soil removal: evaluate major ions concentrations in soil and excavate (not necessary if geosynthetic lined or no evidence of leakage). Removal of 2 ft of soil below retention pond-Assumed not necessary.	\$0.00
	9 Closure Testing (Soil testing for major ions: 4.4 acres with 2-3 samples/acre=10 samples and tests @ \$280 each)	\$0.01
B Corrals		
Capital Costs	1 Liner: Geosynthetic clay liner or a minimum 1 ft compacted clay liner (with permeability of 1×10^{-7} or less)	\$1.00
	2 CQA Testing during installation of low permeability layer (10% of capital costs)	\$0.12
	3 Two foot minimum operations layer (local natural material) (geosynthetic cushion assumed not necessary)	\$0.15
	4 Install Groundwater Monitoring Wells (2 wells @\$3,947.50 each)	\$0.02
Operational Costs	5 Remove manure (source) two times a year @\$3 per CY (2 ft)	\$0.11
	6 Monitor of Groundwater wells (2 wells @\$250 each)	\$0.01
	7 Monitor of Vadose Zone (2 samples & lab testing @ \$175 each)	\$0.01
Closure Costs	8 Closure	
	Removal of operations layer/manure (2 ft layer @ \$3 per CY)	\$0.22
	Test soil for major ions content (13 acres with 2 samples/acre=26 samples and tests @ \$280 each)	\$0.02
	(If concentrations represent a threat to groundwater, excavate 2 ft of below operations/manure layer). Assumed not necessary.	\$0.00
C Milk Parlors		
Capital Costs	1 Concrete water-proof surface treatment (Silicone Dampproofing, sprayed (2 Coats))	\$1.01
	2 CQA testing of concrete during installation (10% of capital costs)	\$0.10
Operational Costs	Annual Maintenance to fill cracks and Inspection of concrete surface (Annual concrete slab cost of \$0.05 plus the capital costs divided by 40 years of operation)	\$0.08
Closure Costs	4 No closure costs.	\$0.00

Evaluation of Alternative Confined Animal Facilities Criteria

Table 5-5 Summary of Costs for Alternative 3

Items		Cost/SF
A Lagoon/Retention Ponds		
Capital Costs	1 Liner consistent with NRCS guidelines (maximum seepage rate of 1×10^{-6} cm/sec with no credit for manure sealing.)	
	1 ft compacted clay @ 1×10^{-6} cm/sec or less	\$0.55
	2 Two foot minimum operations layer (local natural material) \$2/CY (geosynthetic cushion assumed not necessary)	\$0.15
	3 CQA Procedures (10% of capital costs)	\$0.07
	4 Install Groundwater Monitoring Wells (2 wells @\$3,947.50 each)	\$0.04
Operational Costs	5 Annual Maintenance	
	Removal of solids/contaminant source (2 ft) (Assume no additional costs since it is already necessary as a part of normal operations and maintenance.)	\$0.00
	6 Monitor of Groundwater wells (2 wells @\$250 each)	\$0.01
	7 Monitor of Vadose Zone (2 samples & lab testing @ \$175 each)	\$0.01
Closure Costs	8 Closure	
	Removal of Liner (\$4/CY)	\$0.30
	Assume removal of 2 ft of soil below retention pond. Assume \$3 to excavate and \$3 to treat contaminated soil per CY	\$0.44
	9 Closure Testing (Soil testing for major ions: 4.4 acres with 2-3 samples/acre=10 samples and tests @ \$280 each)	\$0.01
B Corrals		
Capital Costs	1 Liner consistent with Kings County Ordinance (naturally occurring clay (not less than 20 percent clay and silt)). *	\$0.50
	2 CQA Testing during installation of low permeability layer (10% of capital costs)	\$0.07
	3 Two foot minimum operations layer (local natural material) (geosynthetic cushion assumed not necessary)	\$0.15
	4 Install Groundwater Monitoring Wells (2 wells @\$3,947.50 each)	\$0.02
Operational Costs	5 Remove manure (source) two times a year @\$3 per CY (2 ft)	\$0.11
	6 Monitor of Groundwater wells (2 wells @\$250 each)	\$0.01
	7 Monitor of Vadose Zone (2 samples & lab testing @ \$175 each)	\$0.01
Closure Costs	8 Closure	
	Removal of operations layer/manure (2 ft layer @ \$3 per CY)	\$0.22
	Test soil for major ions content (13 acres with 2 samples/acre=26 samples and tests @ \$280 each)	\$0.02
	(If concentrations represent a threat to groundwater, excavate 2 ft of below operations/manure layer). Assume removal is necessary. Assume \$3 to excavate and \$3 to treat contaminated soil per CY	\$0.44
*Kings County ordinance criteria used since it was based off of NRCS Guidelines		
C Milk Parlors**		Cost/SF
Capital Costs	1 Concrete per CCR Title 3	\$0.00
	2 CQA testing of concrete during installation (10% of capital costs)	\$0.00
Operational Costs	3 Annual Maintenance to fill cracks and Inspection of concrete surface (Annual concrete slab cost of \$0.05 plus the capital costs divided by 40 years of operation)	\$0.05
Closure Costs	4 No closure necessary.	\$0.00

**Assume current regulations/no new costs



5.2 Total Cost of Alternatives

The costs for implementing each Alternative have a wide range, as does their ability to protect groundwater quality. Each of the Alternatives has been calculated to address the annual operations of the average-sized dairy facility for 40 years with 3 percent inflation.

Net Present Value is determined by the formula $(1+i)^N/\text{Future Value}$. “i” is the interest rate and N is the number of compounding periods (years in this report). Future Value was determined by calculating the capital, maintenance, and closure costs for each Alternative. Since a discount rate of 3 percent was used to account for inflation and therefore, the devaluation of today’s money, the sum of the 40 years provides the Future Value. By plugging these values of interest, compounding interest periods and Future Value into the equation, the NPV is calculated. Therefore, this formula calculates how much money would be needed to be placed in a bank account at the stated interest rate in order to finance 40 years of operation.

The Net Present Value of implementing any of the Alternatives exceeds \$2.4 million. The difference between the Net Present Values hinge on the capital costs incurred today and the closure actions associated with that Alternative. The cost to implement Alternatives 1, 2, and 3, based on the facility dimensions of the average-sized Central Valley dairy, are presented in Table 5-6. Since these costs are based on the average-sized dairy, they are only an estimate of the potential financial impact that will be incurred to the Central Valley dairies in current dollars for 40 years of operation. The difference between costs of the three alternatives is dependent on differing capital and closure costs in addition to the extrapolation of those costs to the average dairy facility over the projected 40 years of operation. The details of the Net Present Values for the Alternatives are presented in Appendix B.

Table 5-6	
Summary of Net Present Value	
	Net Present Value
Alternative 1	\$2,940,000
Alternative 2	\$2,725,000
Alternative 3	\$2,479,000

Alternative 2 is less than Alternative 1 because the capital costs for all of the dairy facility elements are less robust, and therefore, cheaper. As both Alternatives are assumed to prevent groundwater contamination, no excavation of the soil is necessary upon closure. The absence of removing soil at closure keeps the costs consistent and thereby makes the rigor of the capital infrastructure a distinguishing factor.

Alternative 3 has the least capital costs which keep the unit costs low. However, because the capital infrastructure is less than the other Alternatives, it is assumed that leakage from the retention ponds and corrals will occur. As such, an additional depth of 2 ft of soil will have to be removed from both areas. Although not conveyed in the NPV, the closure cost for Alternative 3 is approximately 2.7 times more expensive than Alternatives 1 and 2 because of the excavation of soil. Comparing the most robust approach (Alternative 1) to the

least robust (Alternative 3), the estimated capital costs are \$1,202,434 and \$567,279 respectively. Similarly, comparing the estimated closure cost of these same alternatives, the closure costs are \$629,642 and \$1,725,535 respectively. Alternative 3 yields a lower NPV than Alternative 1 due to the time value discount of the closure cost 40 years in the future.

5.3 Available Funding Sources

Through federal, state, and local programs a variety of bonds, grants, and low interest loans are available for improving groundwater quality. Of the available funds, eligible parties range from non-profit organizations to private businesses.

5.3.1 Environmental Quality Incentives Program (EQIP)

EQIP is administered by the Natural Resource Conservation Service (NRCS) which is funded by the federal Farm Bill of 2002. The program is a voluntary conservation program for ranchers and farmers who promote environmental quality and agricultural production. Financial and technical assistance is available to help install or implement structural and management practices on eligible agricultural land. The program and distribution of funds is done at the state level.

Eligible parties for the EQIP are producers involved in livestock or agriculture production on eligible land. Eligible land consists of, "cropland; rangeland; grassland; pastureland; private non-industrial forestland; and other farm or ranchlands as determined by the Secretary of Agriculture" (NRCS 2004). Eligible parties are able to apply at any time by submitting their applications and proof of eligibility to their local NRCS office. However, the deadline for being considered for the Fiscal Year 2004 was January 30, 2004. Rankings for allocating money to applicants are based on environmental scores obtained by evaluating the project in the context of local, state, and federal priorities.

Priorities for California are based on input from the State Technical Advisory Committee, Local Work Groups and NRCS agency staff recommendations. There are four incentive programs which have been developed to address environmental impacts. The incentives consist of the California Air Quality Initiative, California Ground and Surface Water Conservation (GSWC) Initiative, Klamath Basin Ground and Surface Water Conservation Initiative, and California Regular EQIP Program. In addition to these EQIP Programs, there is a new program called the California County EQIP Program which allows County specified projects to be undertaken as discussed below.

5.3.1.1 California County EQIP Program

All other EQIP programs are geared towards state and national priorities. However, this program provides funds to counties allowing local concerns to be addressed. Counties are able to establish their own priorities and ranking criteria, select practices for cost sharing, and focus on improving target elements in their community. Table 5-7 lists the Central Valley counties that have identified confined animal facilities as a concern in their EQIP program description. Details, if specified, are identified in the table. For the most part, ground and surface water are concerns that will be ranked to allocate money. Several counties have

Final Report

taken the concern a step further by allocating a percentage of EQIP funds to address the confined animal facility problems.

For the rest of the California counties there are broad water quality objectives which have been identified, but not targeted at confined animal facility improvements. There are agricultural communities that have irrigated cropland as a concern with regards to water quality. Although the program is expected to assist industries other than confined animal facilities, the ranking criteria and benefits directed at groundwater from facility improvements does not prevent confined animal facility operators from applying and being awarded funding. For instance, Sutter County has identified in their EQIP Program description that dairies are predominant in their jurisdiction, but the ranking criteria used to allocate funds are not tailored to the industry. In addition to these programs, Napa County has identified that their funds will be used to assist entities in complying with local, state, and federal regulations related to water quality. These programs provide additional financial support to the local community which may not be serviced through the other EQIPs.

Table 5-7	
Counties in the Central Valley Region With Specific Confined Animal Facility Opportunities	
COUNTY	CONFINED ANIMAL FACILITY EMPHASIS
Fresno	Approximately 50 percent of funds to be allocated toward confined animal facilities, mainly dairies. Focus on practices that assist in manure management and protect ground and surface water resources.
Glenn	Improve water quality and animal waste management.
Kern	Funds will be targeted to confined animal operations, mainly dairies, where multiple resource concerns exist.
Kings	Approximately 80 percent of funds will be targeted to applications that address the most significant surface and groundwater concerns from confined animal facilities, mainly dairies.
Madera	Waste management practices on confined animal operations. Approximately 50 percent of funds will be allocated to address the most significant surface and groundwater concerns at these facilities.
Merced	Approximately 80 percent of funds will be targeted to applications that address the most significant surface and groundwater concerns from confined animal facilities, mainly dairies. Priorities include practices that will assist in the management of manure, as well as protect groundwater and minimize or eliminate runoff from confined animal facilities.
Sacramento	Funds for programs addressing animal waste erosion/ sedimentation, groundwater contaminants, pesticides, and non-point source pollution.
San Joaquin	Fund allocation of approximately 30 percent for pollution reduction from confined livestock.
Stanislaus	Approximately 45 percent funding allocation. Focus on programs that address nutrients in groundwater, water management, leaching potential, and salinity management.
Tulare	Approximately 75 percent allocation to confined animal operations, mainly dairies. Focus on programs that address nutrient loading, storage/solid removal, and soil propensity for leaching.

5.3.2 Clean Water State Revolving Fund

This is a low-interest program which provides loans for projects which address point and non-point sources of water pollution. This program is funded by the U.S. EPA and awards between \$200,000 and \$40 million. Public and private entities are eligible for implementation of source control programs.

5.3.3 Dairy Waste Management Loan Program

The Dairy Waste Management Loan Program is administered by the Valley Small Business Development Corporation. This program assists small dairies develop and comply with a nutrient management plan. To be eligible to apply, the facility must have 700 milking cows or less. The loans are offered for a maximum of 15 years with a 5.7% fixed interest rate. The maximum loan amount to any single entity is \$750,000. For freestalls, the maximum loan is \$250,000. For more information about this assistance program, visit www.vsbdc.com.

5.3.4 Proposition 50

Proposition 50 funds have been combined with Proposition 13 into the joint CALFED Drinking Water Quality Program since Propositions have overlaps. For projects desiring to be funded out of Proposition 50, the project must be located in a CALFED solution area or if outside the area, the project must directly achieve the objectives for the Bay Delta system. Regardless, the funded projects will be evaluated against specific selection criteria. Selection criteria for funding are based on nine categories: relevance and importance; scientific merit; monitoring, assessment, and performance measures; coordination, communication, and technology transfer; environmental justice; tribal resources and concerns; project team and budget; costs and benefits; and durability/long-term operation and maintenance. These categories assess the ability of the proposed project to reduce contaminants that impair Delta water quality, the logistics and scientific evaluation that the proposed plan will deliver the anticipated water quality improvements, and evaluate the impacts to the community and the ability of the project to provide water quality benefits for at least 20 years.

Eligible applicants are municipalities, local public agencies, educational institutions, nonprofit organizations, Indian tribes, and state and federal agencies. The minimum funding is \$250,000 with the maximum funding allocation of \$5 million.

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Section 6

Recommendations

Specification of minimum criteria applicable to all confined animal facilities in the Central Valley of California is not feasible because conditions at each facility are different and the risk of groundwater contamination can be significantly different at different facilities. This in turn could require different levels of design, operations, maintenance, and closure to account for these conditions. Accordingly, the selection of appropriate criteria will require consideration of the appropriate performance goal and best profession judgment that at a minimum considers waste toxicity and concentration, input loading, aquifer vulnerability, facility life, closure, preexisting groundwater conditions, and the State's Antidegradation Policy.

Because each facility will be required to at least achieve the least stringent performance goal of no exceedance of water quality objectives (unless the natural background groundwater quality at the facility exceeds water quality objectives), the criteria presented for Alternative 3 to meet that performance goal are recommended as the minimum criteria for all facilities. A particular facility may need to implement more stringent criteria in order to comply with the performance goal of no exceedance of water quality objectives or to comply with a more stringent performance goal.

6.1 Recommended Minimum Criteria

The recommended minimum criteria include criteria for pre-construction, siting, design, construction, operations, maintenance, monitoring, and closure for retention ponds, corrals, and milk parlors. These criteria are summarized in Table 4-4 and are discussed below.

6.1.1 Preconstruction

Preconstruction criteria include site characterization consistent with Chapter 7 of the NRCS Agricultural Waste Management Field Handbook.

6.1.2 Siting

Siting criteria include the following:

- The retention pond, corral, and milk parlor shall be separated by at least five feet from the highest anticipated groundwater elevation;
- Retention ponds and corrals shall be underlain by natural geologic materials of sufficient thickness and with appropriate physical and chemical properties to ensure attainment of the applicable performance goal considering waste characteristics, facility design, construction, operation, maintenance, and closure.



6.1.3 Design

6.1.3.1 Retention Ponds

The criteria for retention ponds includes the following:

- Either a compacted clay liner with a maximum seepage rate of 1×10^{-6} cm/sec, without the crediting for manure sealing, or alternative liner types which provide equal or lower seepage rates.
- The compacted clay liner should be overlain with an operations soil layer. The operations soil layer should be a minimum of two feet thick, and should not contain angular rock fragments or materials that may damage the underlying liner.

6.1.3.2 Corrals

The criteria for corrals include the following:

- Naturally occurring or imported clayey (not less than 20 percent clay and silt) soils shall underlie the corrals and dry manure storage areas;
- Imported clay materials shall be placed and compacted to at least 90% relative compaction for a compacted layer of at least one foot thickness;
- The 20 percent minimum clay and silt must be covered with an operations layer a minimum of two feet thick to provide protection from damage from the animals in the corral. The operations soil should not contain angular rock fragments or materials that may damage the underlying clayey materials; and
- Corrals shall be sloped to drain and convey the drainage water to an appropriate discharge point or location pursuant to CCR Title 3, Division 2, Chapter 1, Article 22.

6.1.3.3 Milk Parlor

The criteria for the milk parlor includes compliance with CCR Title 3, Division 2, Chapter 1, Article 22, which requires, among other things, concrete flooring to be guttered and sloped to drain.

6.1.4 Construction

Construction criteria include the following:

- Retention pond and corral liners shall be in accordance with CQA procedures as specified in Section 20324 of CCR Title 27.
- Installed geomembrane liners shall be tested after installation with an electronic leak detection survey as part of CQA.
- Concrete flooring and gutter construction in the milk parlor shall be tested to ensure conformance with the material specifications.

6.1.5 Operations

Operations criteria include weekly inspections of the retention pond, corral, and milk parlor.

6.1.6 Maintenance

Maintenance criteria include annual removal of solids from the retention pond, semi-annual removal of manure from the corrals, maintaining the required retention pond freeboard, corrections of deficiencies noted during inspections, filling of depressions in the corral, and correction of cracks or defects in concrete floors in the milk parlor. An Operations and Maintenance Plan should also be prepared by the facility operator.

6.1.7 Monitoring

Monitoring criteria include vadose zone and groundwater monitoring of the retention pond and corral to determine background concentrations and to provide for the earliest possible detection of a release.

6.1.8 Closure

Closure criteria include removal of solid and liquid waste and any underlying constructed lining system from the retention pond and corral, testing of subsurface soils for major ions to a depth of 10 feet, and excavation and removal or treatment of any affected soil.

6.2 Approach to Implement Minimum Criteria

As described previously, site-specific conditions will dictate the minimum criteria necessary to meet the appropriate performance goal. These conditions will also dictate the level of BPTC to meet the identified performance goal. Because the factors that affect the risk to groundwater are also site-specific and because there are no rigorous analytical tools currently available to quantitatively account for all of these factors, best professional judgment by appropriately qualified professionals will be necessary to demonstrate compliance with the performance goals.

Predicting the movement of confined animal wastes (particularly $\text{NH}_4^+\text{-N}$) with precision requires the solution of advection-dispersion equations and the use of adsorption-retardation models. Models that consider all of these factors are very complex and require an exhaustive list of input data (e.g. soil chemistry, geology, and hydrogeochemistry). Risk analysis using complex models is too cumbersome and time-consuming to be useful as a regulatory, design, and permit writing tool (Ham and DeSutter, 2000). Simplified computer-based analytical models are available, however, that may be used to predict the fate and transport of animal waste constituents in the subsurface. These models are not generally accepted to accurately model the transformations of some confined animal facility waste constituents that occur in the subsurface (particularly nitrogen compounds), and as a result, the models require a number of assumptions regarding loading concentrations that may be somewhat subjective. However, simplified models may be used to perform multiple

Final Report

screening and sensitivity analyses in a short period of time. In this manner, different assumed levels of contaminant loading can be quickly evaluated to assess potential effects on groundwater quality.

The models used for this investigation (MULTIMED and SEVIEW) represent two examples that are relatively user-friendly and solve a linear advection-dispersion equation, which means that if all other parameters are held constant, the model-predicted concentrations in groundwater are linear functions of the input concentrations (MULTIMED) or loading rates (SEVIEW). This is a useful feature that allows multiple screening and sensitivity analyses to be performed in a short period of time. The steady-state model MULTIMED can be used to predict dilution of contaminants that may leak from a retention pond largely as a function of leakage rate, and to a lesser extent, subsurface conditions. MULTIMED has the advantage of being accepted by the CVRWQCB as a tool to assist in liner demonstration evaluations for Central Valley solid waste disposal facilities. Transient models (such as SEVIEW) are useful because they provide information on the time required for a contaminant to impact the groundwater as a function of input loading rates, contaminant properties, and subsurface conditions.

Although this approach will not provide a quantitative determination that a particular facility will or will not be able to comply with the applicable performance goal, it is suggested as a potential tool that may be used to support best professional judgment. This approach may also be considered by the regulators to identify minimum criteria and when assessing a demonstration of compliance with the performance goal. It is emphasized that any evaluations and resulting best professional judgment must be based on representative site information.

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